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Assessing the Feasibility of an Internal Paper Recycling Plant

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December 11, 2008

Ing. Marcelo Rodríguez Oviedo
Proceso Gestión Documental
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San José, Costa Rica

Dear Sr. Rodríguez:

Enclosed is our report entitled *Assessing the Feasibility of an Internal Paper Recycling Plant*. It was written at the *Instituto Costarricense de Electricidad* during the period from October 21 through December 10, 2008. Preliminary work was completed in Worcester, Massachusetts, prior to our arrival in Costa Rica. Copies of this report are simultaneously being submitted to Professors Robertson and Vernon-Gerstenfeld for evaluation. Upon faculty review, the original copy of this report will be catalogued in the Gordon Library at Worcester Polytechnic Institute. We appreciate the time that you and Mrs. Rosibel Murillo have devoted to us.

Sincerely,

Joseph Alea
Emily Kreek
Austin Ng

Title Page

Report Submitted to:

Professor Thomas Robertson

Professor Susan Vernon-Gerstenfeld

Costa Rica Project Center

By

Joseph Alea _____

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In Cooperation With:

Marcelo Rodríguez, Coordinator

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Instituto Costarricense de Electricidad (ICE), *Gestión Documentación e Información* (GEDI)

ASSESSING THE FEASIBILITY OF AN INTERNAL PAPER RECYCLING PLANT

December 11, 2008

ABSTRACT

Legislation in Costa Rica mandating recycling in government organizations has required the *Instituto Costarricense de Electricidad* (ICE) to recycle paper. ICE was interested in constructing a recycling plant to produce a paper product for sale on the market. We determined the financial feasibility of this project using four separate cost-benefit analyses. Several situations were considered to determine the quantity of paper waste required for this project to become profitable. Ultimately, we recommended that ICE does not construct a recycling plant at this time. Additionally, ICE should maintain its agreement with Kimberly-Clark while increasing paper collection rates and searching for smaller-scale recycling equipment.

EXECUTIVE SUMMARY

Costa Rica is actively trying to become one of the most environmentally friendly countries in the world. President Óscar Arias has stated his goal for Costa Rica to become carbon neutral by the year 2021. In addition, the government is passing legislation encouraging environmental awareness and protection. The Costa Rican government has been encouraging environmental responsibility by mandating recycling in government agencies.

The *Instituto Costarricense de Electricidad* (ICE) is the government owned electricity, telecommunications, and internet service provider in Costa Rica. To comply with the recent legislation, ICE implemented a recycling program in spring 2008. Recycling bins were placed throughout the offices to collect paper waste, which was then exchanged for paper goods from Kimberly-Clark. However, ICE was interested in developing alternate paper recycling methods in order to expedite the recycling process and potentially make a profit from the paper waste.

The goal of our project was to assess the feasibility of constructing an internal paper recycling plant for ICE. The paper recycling plant would allow ICE to produce and sell a semi-completed paper product to other companies for a profit. To achieve this goal we completed the following objectives:

1. We estimated the yearly quantity of paper waste generated by ICE.
2. We determined the space, equipment, utility costs, employees, and operational costs required to construct and operate a recycling plant.
3. We performed a cost-benefit analysis to determine the feasibility of building a recycling plant.

We determined that ICE is collecting approximately 155 metric tons of paper waste per year, which is approximately 30 percent of the paper waste the company generates. ICE's goal is

to recycle 90 percent of its paper waste in the future. In November 2008, we contacted Andritz, an Austria-based manufacturer of paper recycling equipment, and presented our data for the quantity of paper waste that ICE produces annually. We learned that the amount of paper waste ICE generates is not enough to warrant the purchase of paper recycling equipment. ICE currently collects approximately 0.42 metric tons of paper waste a day, and recycling equipment is designed to recycle between 50 and 1000 metric tons of paper per day. Our conclusion that ICE is not collecting enough paper waste was further backed by our research on systems designed by Comer, another manufacturer of paper recycling equipment based in Italy. Comer's smallest systems are designed to process at least 60 metric tons of paper waste per day.

Because of our findings that paper recycling equipment is designed for a larger scale than that of ICE's current paper recycling operation, we recommended that ICE does not build a paper recycling plant at this time. The cost-benefit analysis showed that it would not be financially beneficial for ICE to build a recycling plant unless 63 metric tons of paper waste was collected each day. We suggest that ICE analyze the paper waste situations at other government organizations to determine whether or not ICE can collect fifty metric tons per day from these companies. We also recommend that ICE research solutions offered by recycling equipment manufacturers to determine if there are smaller machines available.

AUTHORSHIP

Section	Main Author	Editors
Executive Summary	Ng	Alea, Kreek
Introduction	Kreek	Alea, Ng
Background	Kreek	Alea, Ng
Methodology	All	All
Results and Analysis	Alea	Kreek, Ng
Recommendations	Alea, Ng	Kreek

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We would like to give special thanks to Ericka Díaz Rodríguez for all her help during this project.

We would also like to recognize the following people for giving us their time to share valuable information:

José Ramirez Hernández, Engineer at GEDI

Edgar David Mesén Araya, Director of International Affairs

Keith A. Meyer, Executive Vice President of Andritz

Lidieth Mata Badilla, Manager of Documentation and Information

Rodolfo Perez Morales, Coordinator of the Institutional Paper Recycling Process

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CHAPTER 1: INTRODUCTION

Recycling has become a major social and business issue (Hussain, 2008). Recycling, a process in which used materials are collected and reprocessed into new products (Pennsylvania Department of Environmental Protection, 2006), has been recognized as an efficient way to manage waste (Environmental Protection Agency [EPA], 2007). Recycling can provide both environmental and economic benefits. These benefits range from protecting forests, lowering energy consumption, and minimizing landfill use to reducing waste disposal costs, providing employment opportunities, and generating revenue for businesses.

Costa Rica is currently trying to become more environmentally responsible. Recent legislation in Costa Rica encourages environmental conservation through both a reduction in consumption and an increase in recycling. However, recycling in Costa Rica begun only recently, and many businesses are not completely familiar with all of the options available for recycling. The *Instituto Costarricense de Electricidad* (ICE) is one of these companies. ICE, the government monopoly that provides Costa Rica's electricity and telecommunications services, is being mandated by the government to become more environmentally responsible. An effective recycling program within ICE can help encourage recycling throughout the country.

In the spring of 2008, ICE developed a pilot recycling program in the *Gestión Documentación e Información* department in Barrio México. Paper was collected in recycling bins located throughout the building and shipped to a storage warehouse in Pavas. The paper was then sorted, shredded, and baled by ICE employees before being picked up by Kimberly-Clark, a paper company. In exchange for the paper waste, ICE received products such as paper towels and toilet paper from Kimberly-Clark.

However, ICE was interested in exploring methods to improve the efficiency and profitability of its paper recycling process. One method tentatively considered was the possibility of constructing an internal recycling plant. ICE was interested developing a recycling plant to produce wet lap, a partially completed paper product of about 50 percent water. The wet lap would be sold to outside paper companies for further processing. A thirty-by-thirty meter building next to the paper storage building in Pavas was being considered for the location of the plant.

In order to determine if the recycling plant would be financially beneficial, ICE needed more information and analysis. The amount and types of paper waste generated by ICE was unknown. This prevented ICE from knowing the appropriate size for an internal recycling plant. Additionally, the requirements for building a recycling plant at ICE were unknown. Information such as the space, equipment, utilities, employees, insurance, and maintenance costs were required to determine the full range of costs associated with building a recycling plant. This information had to be analyzed using a cost-benefit analysis so that ICE could make an informed decision.

The goal of this project was to help ICE decide whether it would be financially beneficial to construct its own paper recycling plant. To achieve this, we completed the following three objectives:

1. We approximated the amount of paper waste produced by ICE.
2. We determined requirements and costs of building and operating a recycling plant.
3. We performed a cost-benefit analysis to determine if building an internal recycling would be profitable.

Additionally, we considered the social impacts of this decision. ICE is a government monopoly that is currently undergoing privatization. In order to save money, ICE will likely encourage employees to recycle as much of its waste as possible. This requires a change in behavior, as employees move from disposing all of their waste in the trash to recycling a large portion of it. Resistance to change among employees could be an obstacle if ICE chooses to pursue this project. We considered this social impact throughout our project.

CHAPTER 2: BACKGROUND

In order to provide the reader with a better understanding of this project, this section will discuss the legislative development of recycling in Costa Rica, the environmental and economic effects of recycling, and potential problems faced by businesses when recycling. Additionally, the obstacle of encouraging behavioral changes in employees is investigated.

RECENT LEGISLATION IN COSTA RICA REGARDING RECYCLING

In order to conserve valuable natural resources, Costa Rica is making an effort to become more environmentally responsible. In 2007, Costa Rican president Óscar Arias announced his goal for Costa Rica to obtain a "carbon neutral" status by the year 2021 (Fresh Plaza, 2008). The term "carbon neutral" describes reducing net carbon emissions to zero. Along with a reduction in fossil fuel consumption and the development of alternative fuels, an important way to achieve this goal is to increase recycling (Burnett, 2008).

According Rodolfo Perez Morales, Coordinator of the Institutional Paper Recycling Process, the recycling initiative at ICE is the result of three specific pieces of legislation: *La Ley Orgánica del Ambiente, el Decreto 23942 Mirenem,* and ICE's own environmental decrees. *La Ley Orgánica del Ambiente*, passed in 1996, is a plan for government to set goals for improving the environment and properly managing natural resources. It includes sections that specifically evaluate the environment actions of government agencies. *El Decreto 23942 Mirenem* of 1995 clearly asserts that paper recycling is a suitable method for conserving natural resources such as trees. It requires government organizations to establish mechanisms to collect and recycle all of the paper they use, and it obligates these organizations to purchase recycled products. Additionally, ICE has taken the initiative to create its own environmental policies. As part of its

Environmental Policy of 2002, ICE declares its own responsibility to sustainably use natural resources.

Rosibel Murillo Rojas, Manager of Quality and Environment at ICE, states that this legislation has compelled ICE to begin recycling. By May of 2008, a pilot recycling program was in place in the GEDI department of ICE. Assuming that recycling is universally beneficial, this is a positive result; however, the potential disadvantages of environmental legislation must be considered. These disadvantages include increased demands on the resources of businesses.

The development of a recycling program can be expensive. Ranging from putting recycling bins within an office to a company's construction of an internal recycling plant, there are many costs associated with recycling. At ICE, two employees and one machine are responsible for sorting, shredding, and baling all of the paper waste. This has created a limitation on the amount of paper that can be collected by Kimberly-Clark. Paper waste remains in the warehouse for months before the employees have time to manage it. It is possible that the addition of another employee or improved machinery would expedite the process and result in additional returns from Kimberly-Clark, but ICE lacks available resources to determine if this would be a worthwhile endeavor. This type of problem can deter businesses from developing efficient methods of recycling.

A major decision under consideration by ICE was whether or not to construct an internal paper recycling plant, which would require a large amount of the company's resources. During this project, cost-benefit analyses were performed to determine if the benefits of selling wet lap would outweigh the costs associated with a recycling plant.

BENEFITS AND DRAWBACKS OF PAPER RECYCLING

Recycling can bring both positive and negative changes to the environment and the economy. Recycling can reduce costs, generate revenue, and provide employment opportunities. Additionally, recycling has been shown to help protect the environment. At the same time, there are also studies and statistics that show recycling to have the opposite effect. These effects must be considered when implementing a recycling project.

Economic Effects of Recycling. Recycling can reduce waste disposal costs. Companies currently paying to dispose of their waste in landfills will benefit from this aspect of recycling. Some recycling companies will pay for paper waste by the kilogram, while others exchange paper products for a company's paper waste. A direct switch from disposing of waste to recycling in this manner is usually profitable. However, ICE was concerned that sending material directly to a recycling company was reducing potential profits from the paper waste.

Recycling has the potential to generate revenue. A company that manufactures products from recycled materials may sell them on the market (Institute for Local Self-Reliance, 2006). ICE was interested in taking advantage of its relatively high paper waste generation through the construction of an internal recycling plant. However, the benefits of this project depend on specific situations. Companies that do not collect a lot of paper waste may be too small to compete with larger paper manufacturers. Their recycling equipment may be less refined, the process too slow, and the costs too high for the program to be worthwhile. The effect of these obstacles on ICE was investigated throughout the project.

Finally, recycling can have a positive effect on employment. Recycling provides jobs for laborers, researchers, and engineers (EPA, 2006). These employment opportunities are beneficial to the general economy. However, for businesses, the need to hire additional employees can be a

strain on financial resources. Depending on the situation, the additional costs of employees can reduce the benefits of recycling.

Environmental Effects of Recycling. Environmental benefits are difficult to quantify financially. Because environmental benefits do not directly affect a company's finances, many companies do not consider them when determining the profitability of a recycling initiative. However, according to Rosibel Murillo Rojas, an important reason for considering internal recycling is to protect the environment. Due to the legislation encouraging recycling, ICE will continue to recycle regardless of the decision about the construction of a recycling plant. However, the environmental benefits of recycling should be considered when developing a recycling program. Recycling can reduce pollution, energy consumption, greenhouse gas emissions, consumption of natural resources, and the need for landfills.

A study conducted by Thorneloe, Weitz, and Jambeck (2007) for the United States EPA found that greenhouse gas emissions can be reduced by recycling programs. An analysis by Lea (1995) has also shown a significant reduction of energy use for recycling paper compared to the process of transforming virgin wood into paper. Additionally, a Franklin Associates study (1995) has shown that recycling saves energy and can reduce pollution. The study showed that the average curbside recycling program prevents over six hundred pounds of greenhouse gases from entering the atmosphere every year.

Recycling is a viable way to keep waste out of landfills (ILACSD, 2008). Landfills have a finite amount of space, and many in Costa Rica are nearing capacity. For example, *El Plan Municipal de Gestión de Residuos Sólidos de Santo Domingo* of February 2008 was developed to address the need to reduce landfill use in Santo Domingo. The city landfill is expected to reach

its capacity by March of 2009. The need to reduce waste disposal in landfills has become evident.

Paper recycling allows reusable materials to return to the manufacturing cycle. This helps reduce the need to use virgin wood (Oskamp, Burkhardt, Schltz, Hurin, Zelenzy, 1998). Although the majority of paper used in Costa Rica is produced outside the country (Export America, 2005), the effect of reducing tree use has benefits that can spread worldwide. Trees absorb carbon dioxide, a greenhouse gas responsible for global warming.

There are also some elements of recycling that are harmful to environment. Newspaper recycling can be harmful because the use of toxic chemicals in the de-inking process can spread harmful chemicals into the environment (Freas, 2006). Additionally, the process of collecting recyclable materials uses additional trucks to pick up the recyclable materials, which can increases pollution from vehicle emissions (Environmental Health Perspectives, 1995). It is important for the quantity of paper being collected and recycled to offset the environmental damage done by the additional vehicles.

Despite potential drawbacks, Costa Rica is a strong advocate of recycling. *El Decreto 23942 Mirenem*, passed in 1995, unequivocally states five facts about recycling: Trees provide important benefits to the environment; it is the responsibility of the state to ensure the sustainable use of natural resources; recycling and using recycled paper products are suitable methods for conserving resources; and the state is responsible to use its purchasing power to encourage the use of recycled products. This decree leaves little doubt that the Costa Rican government believes that recycling is beneficial for the environment.

OBSTACLES WITH PAPER RECYCLING IN LARGE COMPANIES

Due to legislation mandating recycling in government organizations, ICE will recycle its paper regardless of the debate over the benefits of recycling. However, there are obstacles associated with recycling that businesses must overcome in order to have the most profitable program possible. These complications include the quantity of paper being recycled, the recyclability of various type of paper, the finite number of times paper can be recycled, and the fact that recycling still yields waste in the form of sludge.

Quantity of Paper Waste. The quantity of paper waste produced by a company can be an obstacle to particular methods of recycling. According to Keith Meyer, Executive Vice President of the recycling equipment distributer Andritz, Inc., recycling equipment is only available for paper waste production levels of at least fifty metric tons per day. Purchasing this large equipment to recycle smaller quantities of paper waste is costly and results in an inefficient recycling process. For this reason, many companies choose to send their recyclable waste to recycling companies instead of running the process themselves.

If a company is committed to developing an internal recycling plant, there are potential ways to overcome the issue of lower paper waste generation. Internally, a company can encourage increased levels of recycling in order to collect a higher percentage of the paper waste generated. Additionally, a company can collect waste from other organizations in order to reach the rate of fifty tons per day. However, if these efforts fail to reach fifty tons per day, it may be more beneficial for the company to recycle externally.

Recyclability of Various Paper Types. Although paper is one of the easiest materials to recycle (Recycle Now, 2008), some forms of paper are very difficult or even impossible to recycle. According to Keith Meyer, the most commonly recycled paper types are cardboard,

newspapers, magazines, and office waste such as white printed paper and notebook paper. Office waste yields the highest quality of recycled paper, in the form of new printable paper, tissues, and paper towels. Newspapers and magazines can be remade into newspapers or lightweight paper, and cardboard can be made into lower qualities of cardboard.

Other materials, such as carbon paper, thermal fax paper, plastic-coated paper, tissues, napkins, and paper towels are difficult or impossible to recycle. Some paper such as laminated paper can be harmful to recycling equipment. These materials must be sorted from the recyclable paper, and should not be included in estimate of waste paper generated. Sorting these materials takes additional time and can reduce the profitability of recycling programs.

Decreasing Fiber Strength. The quality of paper decreases each time it is recycled (Tappi, 2001). Contaminants and ink that are not completely removed lower the whiteness and quality of the paper. In the pulping process, paper fibers are torn apart and become shorter and weaker, causing the paper to lose strength. As a result, the recycling process can only be completed about five to six times before the paper fibers become too small to hold together (Gateshead Council, 2008, Tappi, 2001, The City of Edinburgh Council, 2008, Woodland Trust, 2008, Waste Online, 2008). For this reason, recycling cannot completely replace the use of trees in the production of paper.

Waste Products from the Recycling Process. Paper recycling does not eliminate the need to dispose of waste. In the paper recycling process, a waste product called sludge is produced. Sludge is leftover material from the recycling process, created from the de-inking process and from leftover fibers that are too short to form paper. Debate exists over the complications of sludge disposal. In the report *Paper Sludge – Waste Disposal Problem or Energy Opportunity*, Douglas Albertson and Kent Pope describe a system for burning sludge for

energy, thereby benefitting from a potential waste problem. However, this system is designed to burn over two hundred tons of sludge per day and is too large and expensive to be practical for smaller recycling operations. The alternative to burning sludge is to simply dispose of it in landfills. Although the mass of sludge of is less than the mass of the original paper waste, this is an issue that can reduce the environmental benefits of recycling.

RESISTANCE TO CHANGE AMONG EMPLOYEES

The success of a recycling program depends on employee participation. The first step of recycling is the collection process, without which there are no materials to recycle. An important component of ICE's recycling initiative to convince employees to recycle when previously they did not have to.

Resistance to change is a common problem in businesses. It is defined as the action employees take when they perceive a change to be a threat (ChangingMinds.org, 2008). Resistance to any major change can occur regardless of whether the change will positively affect employees (Folger & Starlicki, 1999). It is an obstacle that companies must overcome in order to implement changes that benefit the company. If ICE is unable to collect enough paper to efficiently run the recycling process, the recycling effort may become unprofitable.

The main reason for resistance to change is that employees and managers view changes differently. Managers see the opportunity for improvements to the company, while employees see change as disruptive to their jobs (Strebel, 1996). Therefore, ICE managers will need to demonstrate the benefits of recycling to employees. Managers will also have to ensure that recycling is not overwhelmingly disruptive to the workday.

By the start of this project in October 2008, recycling had been in place for almost six months. ICE had distributed press releases and information about the importance of recycling.

Recycling bins were located on or near employee's desks to facilitate recycling. However, there was little analysis on the effectiveness of the recycling initiative. Employees' opinions about the recycling plan were not known. If employees become frustrated with the recycling program and stop participating in recycling, ICE's recycling efforts could fail.

CHAPTER THREE: METHODOLOGY

The goal of this project was to assess the potential for ICE to build an internal paper recycling plant. To achieve this goal we completed the following objectives:

1. We estimated the quantity of paper waste generated by ICE.
2. We determined the space, equipment, utilities, employees, maintenance, and insurance costs associated with constructing and operating a recycling plant.
3. We performed cost-benefit analyses to determine the financial feasibility of constructing a recycling plant.

OBJECTIVE 1: ESTIMATED QUANTITY OF PAPER WASTE AT ICE

In order to determine the amount of waste ICE's paper plant would have to handle, we determined the quantity of paper waste produced by ICE. A study done in 2002 by Rodolfo Perez Morales, Coordinator of the Institutional Paper Recycling Process, provided us with an initial value for the quantity of paper waste.

In order to confirm this number, we obtained purchasing records from the purchasing department at ICE. These records showed the quantity of paper purchased by ICE during the previous year. We approximated the mass of each paper type using standard densities for each paper material to determine the total mass of paper purchased at ICE.

After we approximated the quantity of paper waste generated at ICE, we compared it with the quantity ICE had previously estimated. These numbers were similar, but we decided to average them to determine an appropriate estimate for the quantity of paper waste produced.

OBJECTIVE 2: DETERMINED REQUIREMENTS FOR A RECYCLING PLANT

Our second objective was to obtain data about the space, equipment, utilities, employees, maintenance, and insurance costs necessary for the construction and operation of a recycling plant.

Equipment. In order to learn about types of machinery required for a recycling plant we visited Kimberly-Clark, the plant that currently recycles ICE's paper waste. Kimberly-Clark recycles more paper than ICE, but the recycling process is similar because the paper recycling follows the same general process to become a final paper product. After learning about the basic types of machines that would be necessary for a recycling plant, we researched several large companies around the world that sell the recycling machinery. After compiling a database of company contacts, we e-mailed several of these companies. The e-mail introduced ICE, explained ICE's objective, asked for recommendations about specific machinery that would fit ICE's needs, and requested an estimate for the costs of the machines, shipping and installation. We used this information to determine the machines that ICE should purchase.

Space. At the start of this project, ICE had a building set aside in Pavas for potential use as a recycling plant. We received the dimensions of the building, and we needed to determine if it was appropriately sized for the machinery and equipment ICE would need for its recycling plant. The recycling equipment manufacturers provided us with information about the space requirements for the machines they recommended. We used this information to determine whether the available building in Pavas was large enough for recycling ICE's amount of paper.

Utilities. To estimate the cost of utilities, we researched the amount of electricity and water required to recycle one ton of paper. We obtained the unit cost of electricity from the *Compañía Nacional de Fuerza y Luz*, and Kimberly-Clark provided us with the cost for water.

Once we obtained those values we were able to calculate an approximation for the total costs of each utility.

Employees. Another cost for the recycling plant was employee salaries. To determine how many employees would be needed, we obtained information from the recycling equipment manufacturers. These companies also provided us with information about the qualifications necessary for these employees. We then obtained information about the salaries and benefits required for various levels of ICE employees from the payroll department of ICE.

Maintenance and Insurance Costs. We searched for reports about standard maintenance and insurance costs for businesses. We were unable to find a standard value for maintenance costs, so we made an approximation based on the general range of maintenance costs in various types of plants. We found a standard percentage for insurance costs based on the value of equipment, and we used that percentage to calculate the yearly insurance cost for the recycling plant.

OBJECTIVE 3: PERFORMED COST-BENEFIT ANALYSES

The third objective of our project was to perform a cost-benefit analysis to determine whether building a recycling plant would be financially feasible. We choose to perform cost-benefit analyses because they provide quantitative data about the financial feasibility of implementing a project.

Costs. We determined the majority of the direct costs for the construction of a paper recycling plant from the methodology used in our second objective. We applied these costs, including equipment, utility, employee, insurance, and maintenance related costs, in our cost-benefit analysis. Another cost we analyzed was the loss of the contract with Kimberly-Clark that would occur if ICE constructed an internal recycling plant. If ICE built its own recycling plant,

ICE would no longer receive goods from Kimberly-Clark. Therefore the loss of these goods would be a cost for ICE. We calculated the value of these paper goods from Kimberly-Clark and included it as a cost in our cost-benefit analysis.

Benefits. The primary monetary benefit for the recycling plant was the creation of wet lap that could be sold on the market for profit. We researched the current values of wet lap that would be created and used this to determine the benefits for ICE. We also knew that there were environmental and publicity benefits from building a recycling plant. However, these benefits were not factored into our cost-benefit analysis for two reasons. Due to the intangibility of environmental and publicity benefits, applying a quantitative value is difficult. Also, ICE wanted to determine the feasibility of maintaining a recycling plant from a financial standpoint.

Analysis. Once we knew the costs and benefits associated with the project, we performed cost-benefit analyses with several different scenarios. This helped us determine if the recycling plant would be beneficial if several factors changed.

Currently, only about 30 percent of the paper waste at ICE is being recycled, which amounts to 155 tons a year based on our calculation. ICE's goal is to recycle 90 percent of its paper. Therefore we performed a costs benefit analysis with both numbers so that ICE could see how the profitability of the plant would change if recycling increased at the company. In several instances of our cost-benefit analysis we needed to perform currency conversions from United States dollars to the Costa Rican colones. Our conversions occurred when the value of one dollar was equivalent to ₡558.65.

We used the Net Present Value (NPV) model and for our cost-benefit analysis. NPV shows the initial costs related to constructing a recycling plant in comparison to monetary savings over the recycling plant's lifetime. It is used to assess the financial feasibility of

implementing a long-term project. We used Equation 1 to determine the initial investment needed to construct the recycling plant, the break-even point, and the recycling plant's lifetime benefits for ICE. The break-even point occurs when the project's total costs equal the total benefits.

Equation 1. Net Present Value

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0$$

Where:

t = the time of cash flow
T = the total time of the project
r = the discount rate
C_t = the net cash flow at time t
C_0 = the initial cost at the beginning of the investment (t = 0)

(My Stock Market Power, 2008)

POSSIBLE INACCURACIES IN OUR DATA

One of the major problems with our data collection was determining an accurate estimate for the amount of paper waste generated by ICE. Due to petty cash paper purchases, we were unable to determine a completely accurate value for the amount of paper waste that ICE generated. Additionally, paper sent or received through mail was not included in our estimate. We instead assumed that the mass of incoming mail would approximately equal that of outgoing mail, thus negating its importance. The value we ultimately obtained for paper waste was small compared to the paper quantity needed for the plant to be feasible. Therefore, the calculations involving the estimated value of paper waste did not significantly affect our results.

There were also complications with obtaining information about the costs and types of machinery needed for the recycling plant. This was due to the lack of sources providing this

information. The majority of the companies that sold the recycling machinery were not interested in working with ICE because ICE did not produce enough paper waste. Therefore, it was difficult to obtain complete data about equipment and costs associate with the recycling plant. Additionally, we were unable to find companies that sell equipment for recycling paper waste in quantities that ICE produces. However, it is possible that such companies do exist.

CHAPTER FOUR: RESULTS AND ANALYSIS

This chapter provides the data we collected about a potential paper recycling plant at ICE. Each section discusses the quantitative values for each of the individual components necessary for the construction of a recycling plant. We conducted cost-benefit analyses to understand the potential for constructing a recycling plant in respect to the amount of paper waste ICE produces.

FINDING 1: ICE GENERATES 515 TONS OF PAPER WASTE PER YEAR

A study conducted in 2002 by Rodolfo Perez Morales, Coordinator of the Institutional Paper Recycling Process at ICE, determined that 144 metric tons of paper waste are collected from within ICE each year. This was estimated to be approximately 30 percent of the total recyclable paper waste in ICE. From this estimate, we calculated that ICE generates approximately 480 tons of paper waste per year.

According to purchasing records with values over ₡4,000,000, ICE buys approximately 549 tons of paper per year. Because the two values of paper waste generation differed, we averaged the two numbers to obtain an estimate value for the paper waste generated by ICE. The final estimate we obtained was 515 tons of paper waste generated a year. Using our approximated value of 515 tons of paper waste we calculated the 30 percent recycling rate to be 155 tons a year, 0.42 tons per day. We also calculated that ICE would generate 464 tons of paper waste per year, or 1.27 tons per day, if the company meets its 90 percent recycling goal. These values were used in our cost-benefit analysis in determining the profit for the respective weights of paper.

FINDING 2: COSTS AND BENEFITS OF RECYCLING PLANT

This section discusses our findings for the costs and benefits associated with the construction of a recycling plant.

Machinery Costs. The data we received from Andritz, Inc., showed that ICE would need approximately ten machines to run the recycling process up to the production of wet lap. These machines would run the processes of pulping screening, de-inking, cleaning, washing, thickening, dispersing, bleaching, deflaking, and refining. The total cost of these machines, including installation, is approximately ₡33,519,000,000. According to Keith Meyer, the lifetime of the recycling equipment is approximately twenty years.

Space Requirement. By the start of our project, ICE had set aside a thirty-by-thirty meter building in Pavas for the anticipated paper recycling facility. A floor plan made by Lidieth Mata Badilla, Manager of Documentation and Information, took into account the location of the entrance of the building, personal facilities that the employees would need, security points, space needed to sort paper into types and enough space in-between machines to prevent overheating. Figure 1 shows the plant in Pavas. However, the floor plan was created before enough research was done on the amount of machinery that would be needed for the recycling plant.

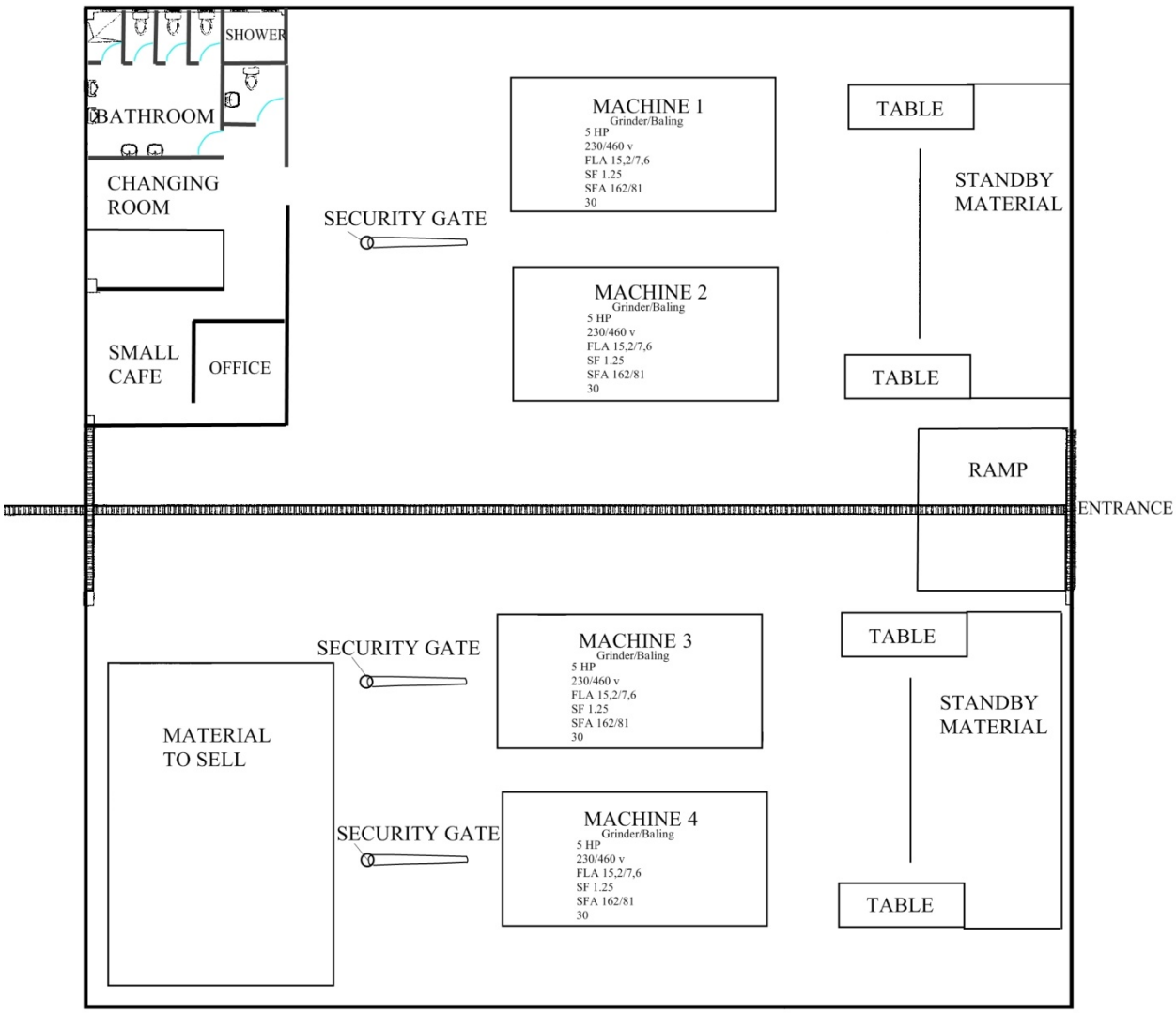

Figure 1. Floor Plan of Recycling Plant in Pavas
(Mata, 2008)

According to the floor plan, the recycling machinery will be located in the central area of the recycling plant. This floor plan would be ideal if ICE only purchased new paper shredders and balers to expedite the paper shredding process. However, the floor plan does not consider the extra machinery ICE would need to produce wet lap; therefore, the floor plan is inaccurate. In addition, if ICE greatly increased the amount of paper waste that was collected the current space set aside for the recycling plant would be too small.

The machinery at Kimberly-Clark was located in several different buildings because of its size and the energy that the machines consume. After our tour at Kimberly-Clark we concluded that creating a floor plan for a thirty-by-thirty meter building would not be possible. If ICE were to continue with the project of creating wet lap, a larger building would be required.

Utility Costs. According to Jennifer Berry (2008) and the California Integrated Waste Management Board (2002), every ton of paper recycled saves approximately 4000 kilowatts of electricity and 27.3 cubic meters of water. This saves 64 percent of the electricity and 58 percent of the water used to create virgin paper. Because we were not able to obtain a value for the amount of electricity and water that is needed for the recycling plant we used the estimated values of 4000 kilowatts of electricity and 27.3 cubic meters of water to approximate the total amount of electricity and water needed to recycle one ton of paper. Table 1 shows the figures we used to calculate the amount of electricity and water needed to recycle one ton of paper.

Table 1. Amount of Electricity and Water Needed to Recycle

Utility	Amount saved for recycling one ton of paper	Percent of total saved	Amount for the creation of virgin paper	Amount for recycling one ton of paper
Electricity	4000 kilowatts	64%	6250 kilowatts	**2250 kilowatts**
Water	27.3 cubic meters	58%	47.1 cubic meters	**19.8 cubic meters**

The cost of electricity is ₡640 for the first 20 kilowatts of electricity used each month and ₡32 for each additional kilowatt. The current price for water is ₡14,718 per cubic meter for the first 15 cubic meters used each month and ₡981 for each additional cubic meter. The amount of paper ICE recycles will determine how much of each utility will be used yearly. Table 2 shows the monthly and yearly costs of electricity and water for the situations of 30 and 90 percent recycling rates.

Table 2. Costs of Electricity and Water Applied to Amount of Paper Waste

Electricity	30 percent recycling rate	90 percent recycling rate	Water	30 percent recycling rate	90 percent recycling rate
Amount of paper recycled per year	155 tons	464 tons	**Amount of paper recycled per year**	155 tons	464 tons
Amount of kilowatts for one ton of paper	2250 kilowatts	2250 kilowatts	**Amount of cubic meters for one ton of paper**	19.8 cubic meters	19.8 cubic meters
Total kilowatts used per year	348,750 kilowatts	1,044,000 kilowatts	**Total cubic meters used per year**	3,069 cubic meters	9,187.2 cubic meters
Total kilowatts used per month	29,063 kilowatts	87,000 kilowatts	**Total cubic meters used per month**	256.8 cubic meters	765.8 cubic meters
Cost per kilowatt	₡32	₡32	**Cost per cubic meter**	₡981	₡981
Total cost per month	₡930,000	₡2,784,000	**Total cost per month**	₡250,891	₡751,054
Total cost per year	₡11,160,000	₡33,408,000	**Total cost per year**	₡3,010,689	₡9,012,643

The total costs for electricity and water if ICE were to recycle 30 percent of its paper waste would be approximately ₡14,170,689 per year. It would cost ICE ₡42,420,643 per year for a 90 percent recycling rate.

Employee Costs. ICE would need to hire various new employees in order to operate the recycling plant. According to our interview at Kimberly-Clark, approximately three unskilled laborers would be needed to run each machine. Additionally, the recycling plant would require three supervisors in total. In order to determine the salaries for laborers and supervisors we used a database of wages for ICE employees based on job title. Because there was not a job title associated with the operation of recycling equipment, we chose to use the job title of "miscellaneous laborer" to approximate the salary of an unskilled laborer. According to the database, miscellaneous laborers at ICE are paid at a rate of ₡227,550 per month or ₡2,730,600 per year. Supervisors are paid at a rate of approximately ₡400,000 per month or ₡4,800,000 per year. We did not to include the increase in salary for hired employees whom are college educated, because we assumed that these laborers would not have professional degrees.

According to Ericka Díaz Rodriguez, Graphic Designer at ICE, employees typically receive an 8 percent increase in salary for each year of employment at ICE. While we factored the 8 percent increase in salary for each employee in our cost-benefit analysis we did not include the probability of job termination. The amount of money from job termination that could skew our final results is minimal and would be counterbalanced by the increased starting salaries of professional employees. In addition we included employee benefits in our calculation. ICE pays an additional 39 percent of an employee's salary for social security, medical insurance, and a retirement plan. Table 3 represents the total employee cost for laborers and supervisors with yearly 8 percent increase in salary for the first five years.

Table 3. Employee Salaries for New Recycling Plant

Year	Position	Yearly salary per employee	Salary with benefits per employee	Number of Employees	Total Yearly Salary
Year 1	Laborer	₡2,730,600	₡3,795,534	30	₡113,866,020
	Supervisor	₡4,800,000	₡6,672,000	3	₡20,016,000
				Total:	**₡133,882,020**
Year 2	Laborer	₡2,949,048	₡4,099,177	30	₡122,975,302
	Supervisor	₡5,184,000	₡7,205,760	3	₡21,617,280
				Total:	**₡144,592,582**
Year 3	Laborer	₡3,184,972	₡4,427,111	30	₡132,813,330
	Supervisor	₡5,598,720	₡7,782,221	3	₡23,346,662
				Total:	**₡156,159,988**
Year 4	Laborer	₡3,439,770	₡4,781,280	30	₡143,438,409
	Supervisor	₡6,046,618	₡8,404,799	3	₡25,214,397
				Total:	**₡168,652,787**
Year 5	Laborer	₡3,713,951	₡5,162,392	30	₡154,871,757
	Supervisor	₡6,530,347	₡9,077,182	3	₡27,231,547
				Total:	**₡182,155,010**

Maintenance Costs. We were unable to obtain a standard accepted value for maintenance costs due to their variation based on the type of equipment, the age of the equipment, and the frequency with which it is utilized. Therefore, we approximated that the cost of maintenance would increase from an initial cost of zero to approximately 40 percent of the initial equipment cost by the end of its lifetime. While our approximation for the cost of maintenance could be debated, the process we used can be applied with more accurate values at a later date. Table 4 shows our approximation for the costs of maintenance for the first five years of the paper recycling plant.

Table 4. Maintenance Costs Over Five Year Time Period

Year	Initial Cost of Machinery	Percent of Initial Cost of Machinery used for Maintenance	Cost of Maintenance
Year 1	₡33,519,000,000	0%	**₡0**
Year 2	₡33,519,000,000	5%	**₡1,675,950,000**
Year 3	₡33,519,000,000	7%	**₡2,346,330,000**
Year 4	₡33,519,000,000	9%	**₡3,016,710,000**
Year 5	₡33,519,000,000	11%	**₡3,687,090,000**

Insurance Costs. According to a Plant Services article, insurance costs in the United States range from 0.1 percent to 0.3 percent of the asset value of the plant (Studebaker, 2007). Because we were unable to interview an insurance company during this project, we used a value of 0.2 percent to approximate insurance costs. Because the estimated value of the machinery for the recycling plant is ₡33,519,000,000, the insurance costs will be approximately ₡67,038,000 per year.

Agreement with Kimberly-Clark. ICE has an agreement with Kimberly-Clark in which ICE shipped its paper waste to Kimberly-Clark in exchange for toilet paper, paper towels, and napkins. Kimberly-Clark placed set values for the various types of paper waste that was collected from ICE. Table 5 shows a complete list of the different paper waste Kimberly-Clark received from ICE with its respective values.

Table 5. Value of Types of Paper Waste

Type of paper	Value(₡/kg)
White printed paper	160
Pure white paper	180
Mixed paper(unsorted)	60

The current two-year contract with Kimberly-Clark, signed on June 6, 2008, has an estimated value of ₡24,000,000, or ₡12,000,000 per year. The contract is valued for 12 metric tons of waste per month, or 144 metric tons per year. If ICE meets its goal of increasing its recycling rate from 30 percent to 90 percent of its paper waste, the value of the contract would triple to ₡36,000,000 per year. The current value of the contract and the theoretical value of the contract at 90 percent recycling were used in separate cost-benefit analyses to determine the feasibility of a recycling plant considering different scenarios.

Value of Completed Product. According to Kimberly-Clark, the current paper recycling industry standard is a 70 percent yield of completed paper product from raw paper waste. This value varies based on the quality of the paper waste, the contaminants it contains, and the number of times it has previously been recycled, but we chose to use the 70 percent value for our calculations.

At the current rate of 155 metric tons of paper being recycled per year, ICE would be expected to produce about 109 metric tons of recycled paper. If ICE reaches the goal to recycle 90 percent of its paper waste, the company would produce approximately 325 tons of paper products per year. The current market value of these recycled paper products is approximately ₡1,098,432 per ton of paper.

Table 6. Yearly Revenue from Wet Lap

Amount of paper waste recycled	Number of tons of reusable paper	Market Value per ton of paper	Total Yearly Revenue
30 percent of paper waste recycled	109 tons	₡1,098,432	₡119,729,088
90 percent of paper waste recycled	325 tons	₡1,098,432	₡356,990,400

The expected revenue from the sales of wet lap would be ₡119,729,088 per year if ICE were to continue recycling 30 percent of its paper waste. If ICE were to increase the amount of paper waste collected to 90 percent then the expected revenue from the sales of wet lap would be ₡356,990,400 per year.

FINDING 3: FINANCIAL FEASIBILITY OF A RECYCLING PLANT

Our cost-benefit analyses allowed us to quantitatively represent the feasibility of constructing a recycling plan. According to José Salas, Advisor for Chamber of Industries, the current discount rate in Costa Rica is between 12 and 15 percent. We used a 13 percent discount rate in our NPV equation for our cost-benefit analyses. We also assumed that that the lifetime of the project would be equivalent to the twenty-year lifetime of the machinery. Table 7 shows a complete list of the costs and benefits discussed earlier that we considered in our cost-benefit analyses.

Table 7. Identified Costs and Benefits

Costs	Benefit
Machinery	Sale of wet lap
Employees	
Electricity	
Water	
Maintenance	
Insurance	
Loss of agreement with Kimberly-Clark	

After identifying the costs and benefits, values were appropriately assigned depending on the quantity of paper waste ICE collected.

Cost-Benefit Analysis for 30 Percent Collection Rate. The following table shows the first year costs associated with constructing a paper recycling plant assuming that 30 percent of the paper waste is collected.

Table 8. First Year Costs of Recycling Plant (30 Percent Paper Waste)

First Year Costs		
Machinery		₡33,519,000,000
Employees		₡133,882,020
Electricity		₡11,160,000
Water		₡3,310,689
Maintenance		₡0
Insurance		₡67,038,000
Loss of Agreement with Kimberly-Clark		₡12,000,000
	Total Costs:	**₡33,746,090,709**

After assigning values to the associated first year costs for of implementing the paper recycling plant, we assigned values to the first year benefits of running the recycling plant. The only benefit would be selling wet lap at yearly value of ₡119,729,088. After compiling all the costs and benefits we applied the values into the NPV equation and determined the cash flow of implementing the project over a twenty-year period. Table 10 shows the total costs, total benefit, yearly net present value and cumulative net present value for the first four years of implementing the project. Appendix D shows the complete cost-benefit analysis for the twenty-year lifetime of the project for the situation in which ICE continues to recycle 30 percent of its paper waste.

Table 9. Cash Flow of Recycling Project for Four-Years (30 Percent Paper Waste)

Cash Flow	Year 1	Year 2	Year 3	Year 4
Machinery	₡33,519,000,000	₡0	₡0	₡0
Employees	₡133,882,020	₡144,592,582	₡156,159,988	₡168,652,787
Electricity	₡11,160,000	₡11,160,000	₡11,160,000	₡11,160,000
Water	₡3,010,689	₡3,010,689	₡3,010,689	₡3,010,689
Maintenance	₡0	₡1,675,950,000	₡2,346,330,000	₡3,016,710,000
Insurance	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000
Agreement with Kimberly-Clark	₡12,000,000	₡12,000,000	₡12,000,000	₡12,000,000
Total Costs	**₡33,746,090,709**	**₡1,913,751,271**	**₡2,595,698,677**	**₡3,278,571,476**
Present Value Costs	₡33,746,090,709	₡1,693,585,195	₡2,032,812,810	₡2,272,214,494
Sales of Wet Lap	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088
Total Benefits	**₡119,729,088**	**₡119,729,088**	**₡119,729,088**	**₡119,729,088**
Present Value Benefits	₡119,729,088	₡105,954,945	₡93,765,438	₡82,978,264
Yearly Net Present Value	-₡33,626,361,621	-₡1,587,630,250	-₡1,939,047,372	-₡2,189,236,230
Cumulative Net Present Value	-₡33,626,361,621	-₡35,213,991,871	-₡37,153,039,243	-₡39,342,275,473

According to this analysis, ICE would lose money every year during the implementation of this project. At the end of the twentieth year the net present value is -₡72,874,498,703 (see Appendix D). As shown in Figure 2, there is no break-even point for this situation. Therefore, it would not be financially beneficial for ICE to implement this project at the current collection rate of 30 percent.

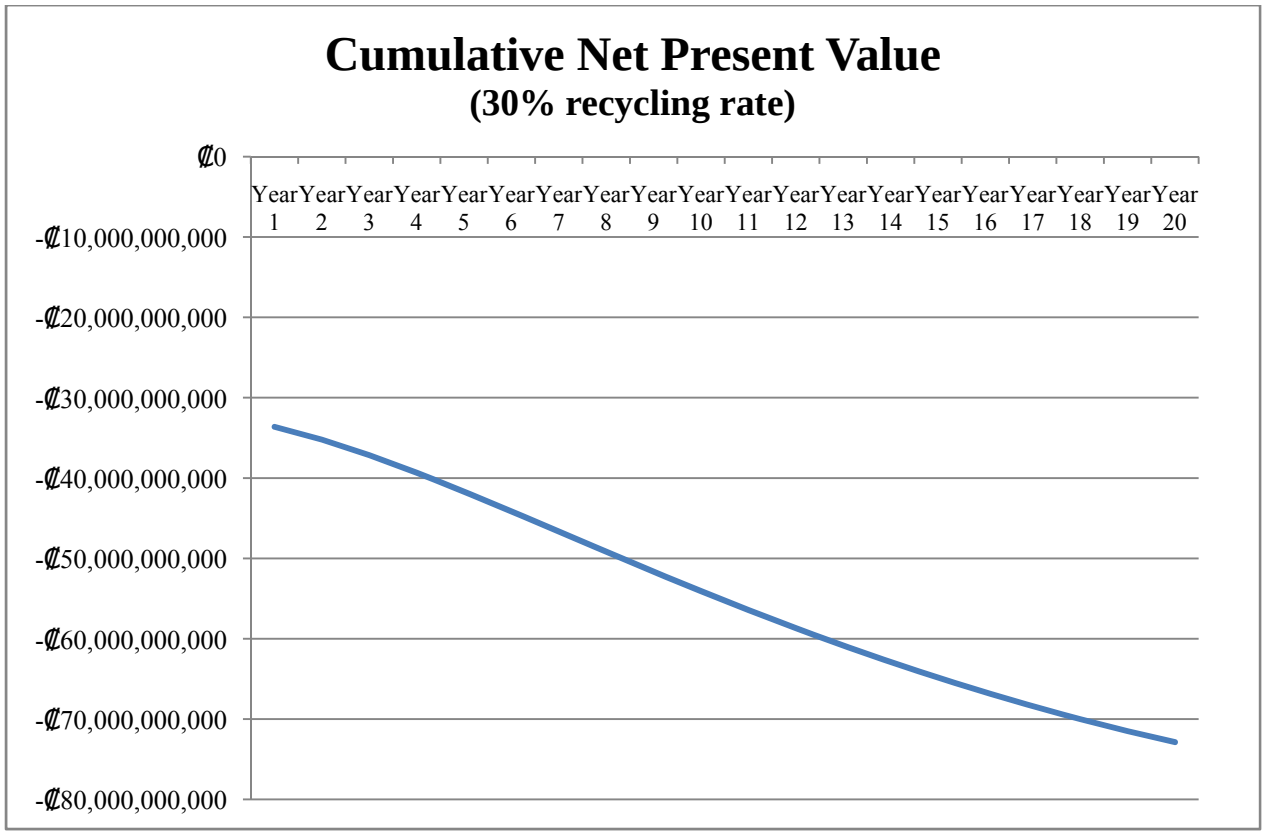

Figure 2. Cumulative Net Present Value for Twenty Years (30 Percent Paper Waste)

Cost-Benefit Analysis for 90 Percent Collection Rate. The second cost-benefit analysis was performed to represent the situation in which ICE meets its goal of recycling 90 percent of its paper waste. Under this situation, the benefits from the project should be three times higher than recycling 30 percent of paper waste. The following table shows the first year costs associated with constructing a paper recycling plant assuming that ICE meets its goal to recycle 90 percent of its paper waste.

Table 10. First Year Costs of Recycling Plant (90 Percent Paper Waste)

First Year Costs	
Machinery	₡33,519,000,000
Employees	₡133,882,020
Electricity	₡33,408,000
Water	₡9,012,633
Maintenance	₡0
Insurance	₡67,038,000
Loss of Agreement with Kimberly-Clark	₡36,000,000
Total Costs:	**₡33,798,340,663**

The only difference between the costs of implementing a recycling plant collecting 30 percent versus 90 percent of the paper waste is the utility costs. Electricity and water costs would increase due to the higher quantity of paper waste being recycled. In addition, ICE would receive higher total profit from selling wet lap. ICE would receive ₡356,990,400 per year if 90 percent of its paper waste were recycled.

These values were applied the values into the NPV equation to determined the cash flow for implementing the project over a twenty-year period at the 90 percent recycling rate. Table 11 shows the total costs, total benefit, yearly NPV and cumulative NPV for the first four years of project. See Appendix E for a complete cost-benefit analysis of the entire twenty years of the project at the 90 percent recycling rate.

Table 11. Cash Flow of Recycling Project for Four-Years (90 Percent Paper Waste)

Cash Flow	Year 1	Year 2	Year 3	Year 4
Machinery	₡33,519,000,000	₡0	₡0	₡0
Employees	₡133,882,020	₡144,592,582	₡156,159,988	₡168.652.787
Electricity	₡33.408.000	₡33.408.000	₡33.408.000	₡33.408.000
Water	₡9.012.643	₡9.012.643	₡9.012.643	₡9.012.643
Maintenance	₡0	₡1,675,950,000	₡2,346,330,000	₡3,016,710,000
Insurance	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000
Agreement with Kimberly-Clark	₡36,000,000	₡36,000,000	₡36,000,000	₡36,000,000
Total Costs	**₡33,798,340,663**	**₡1,966,001,225**	**₡2,647,948,631**	**₡3,330,821,430**
Present Value Costs	₡33,798,340,663	₡1,739,824,093	₡2,073,732,188	₡2,308,426,333
Sales of Wet Lap	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400
Total Benefits	**₡356,990,400**	**₡356,990,400**	**₡356,990,400**	**₡356,990,400**
Present Value Benefits	₡356,990,400	₡315,920,708	₡279,575,848	₡247,412,255
Yearly Net Present Value	-₡33,441,350,263	-₡1,423,903,385	-₡1,794,156,341	-₡2,061,014,078
Cumulative Net Present Value	-₡33,441,350,263	-₡34,865,253,648	-₡36,659,409,989	-₡38,720,424,067

Similar to our first cost-benefit analysis at the 30 percent recycling rate, this situation has no break-even point (see Figure 3). This would result in a continuous loss of money every year. By the end of the twentieth year ICE would have lost a total of ₡71,405,878,228 (see Appendix E). However, the 90 percent recycling rate results in a loss of ₡1,468,614,475 less than with the 30 percent rate. Therefore, a higher level of paper waste collection will result in smaller losses for the company.

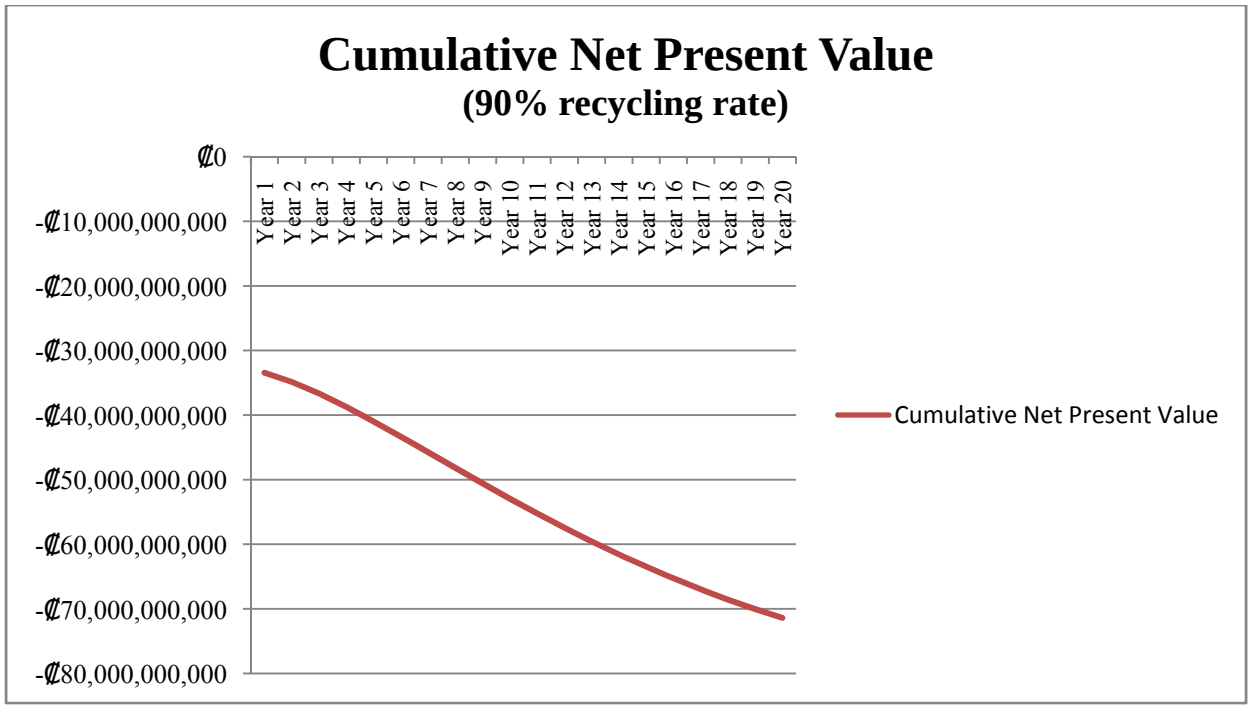

Figure 3. Cumulative Net Present Value for Twenty Years (90 Percent Paper Waste)

Break-even Point. According to our first two cost-benefit analyses, ICE currently does not have enough paper waste to make this project profitable regardless of the recycling rate. However, a break-even point can be found for larger quantities of paper waste. In order to make this project successful ICE must collect more paper. ICE would need to recycle a minimum of 42 tons of paper per day in order to make a profit. See Appendix F for the cost-benefit analysis for recycling 42 tons of paper waste per day for a twenty-year time period. Figure 4 shows the period where income from sales of wet lap equals the invested costs of the project.

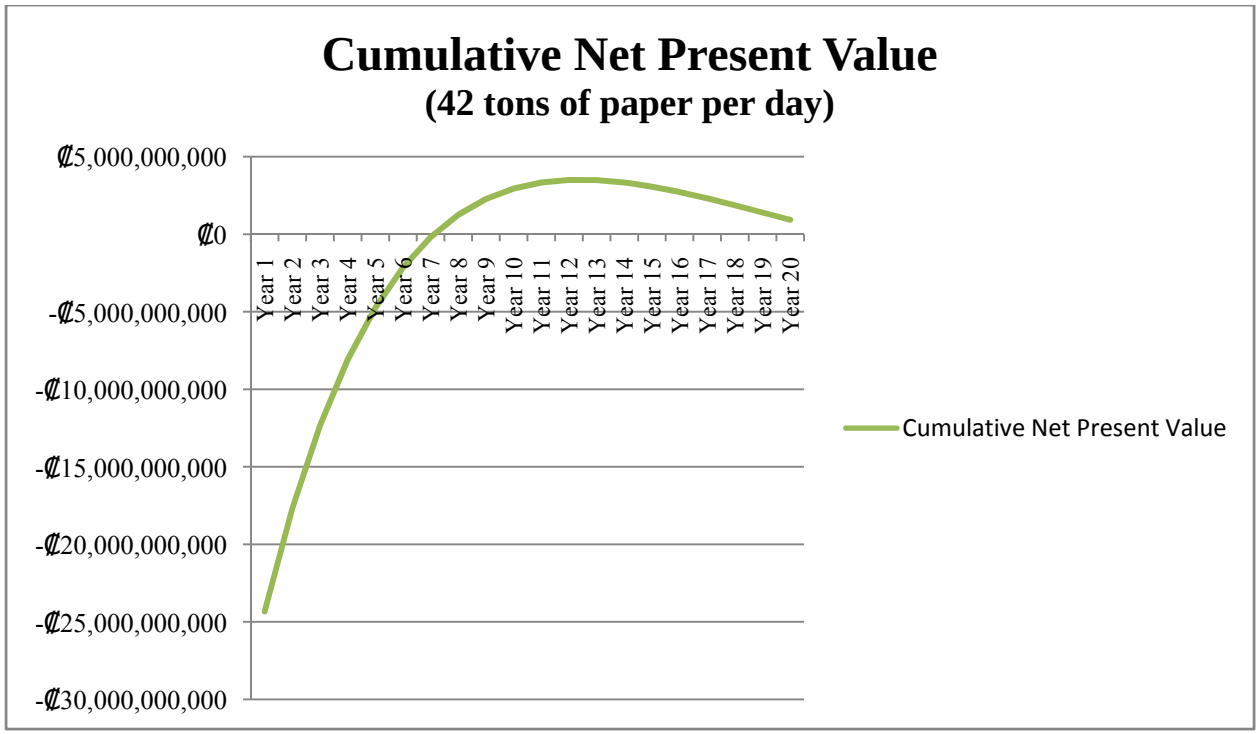

Figure 4. Cumulative Net Present Value (42 tons of paper per day)

While the break-even point is between the sixth and seventh year of implementing the project and ICE would maintain a net profit by the end of the twentieth year, there is a period of time where ICE would begin to lose money. Between the twelfth and thirteenth year of implementing the project, the costs of operating the recycling plant are expected to exceed the profit earned from selling wet lap (see Figure 5).

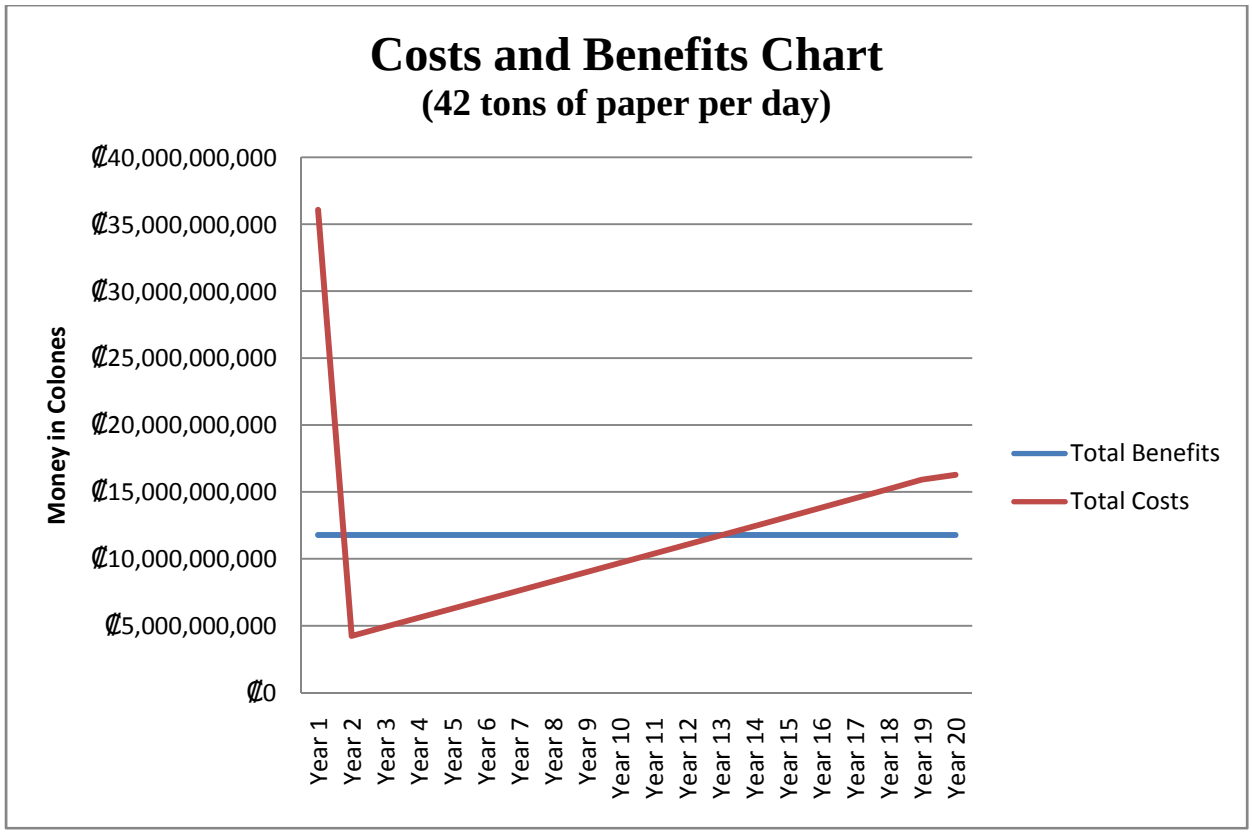

Figure 5. Costs and Benefits Chart (42 tons of paper per day)

At a recycling rate of 42 tons of paper waste per day, the recycling plant would begin to lose money between the twelfth and thirteenth year of the project.

In order to maintain a yearly net profit, ICE would need to recycle a minimum of 63 tons of paper waste every day. At this rate, ICE would make a net yearly profit during the entire duration of the project. Figure 6 show that the break-even point occurs between the second and third year of implementing the project while recycling 63 tons of paper per day. See Appendix G for the cost-benefit analysis performed for the rate of recycling 63 tons of paper over a twenty-year time period.

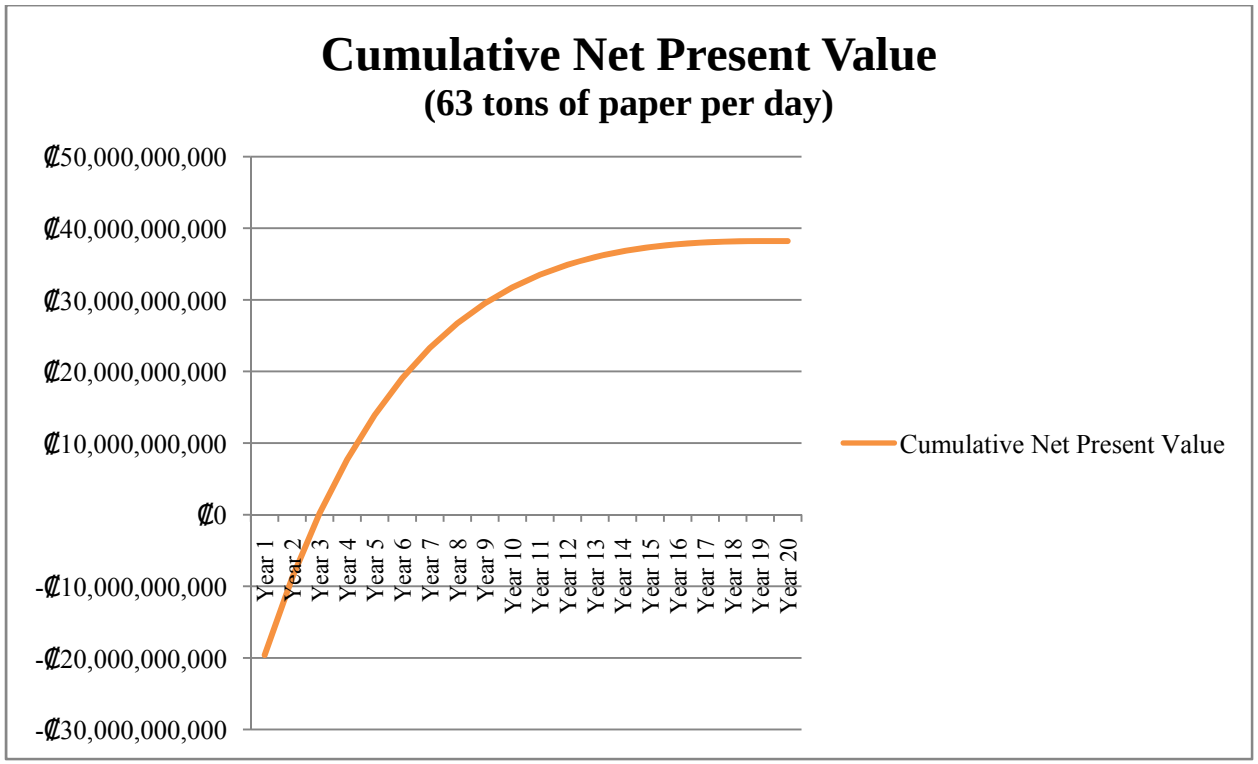

Figure 6. Cumulative Net Present Value (63 tons of paper per day)

In order for a paper recycling plant to be profitable each year over the twenty-year lifetime of the project, ICE would need to collect a minimum of 63 tons of paper waste per day. Figure 7 shows that the total costs of maintenance, utilities and employees do not exceed the revenue from the wet lap throughout the twenty-year time period.

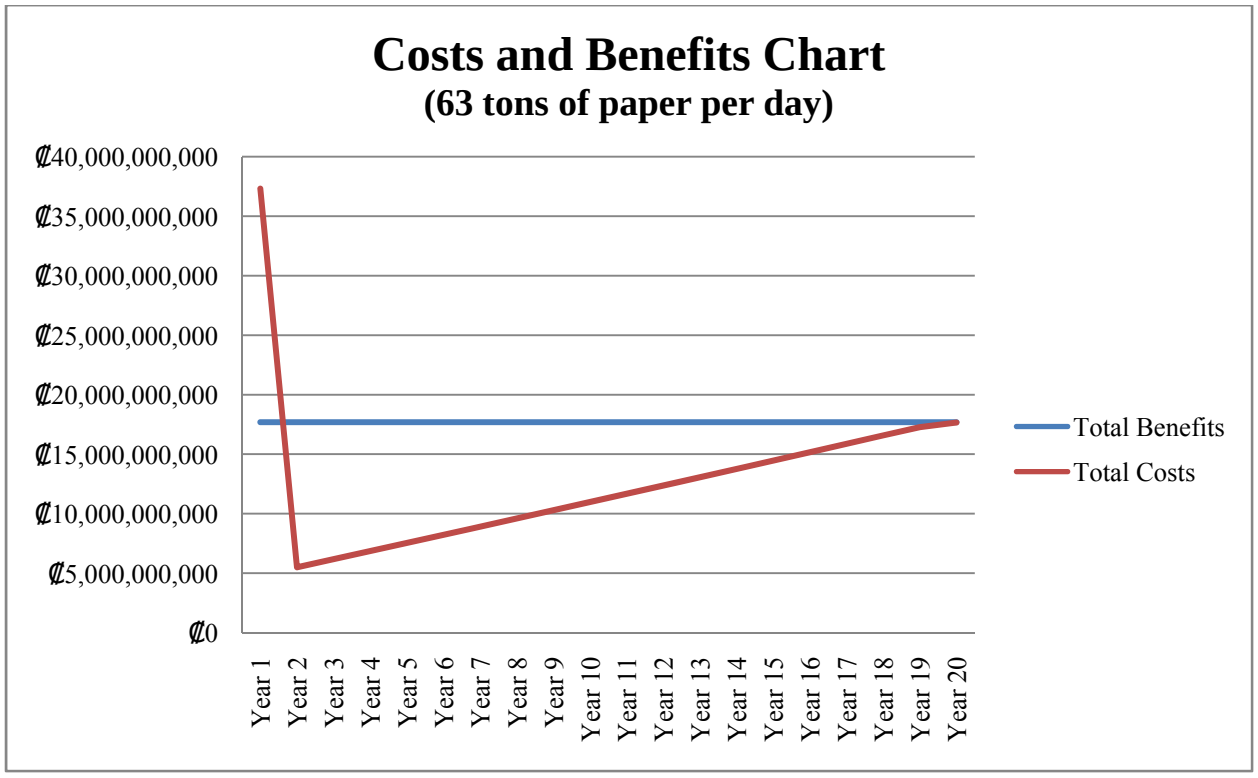

Figure 7. Costs and Benefits Chart (63 tons of paper per day)

With the current amount of 155 tons of paper waste per year (0.42 tons per day), ICE would need to collect 150 times the amount that is currently collected to reach 63 tons per day. In the near future, this task seems difficult if not impossible. ICE could consider importing paper waste from other companies. However, a large amount of companies would be needed to collect 63 tons of paper per day, assuming they all generate similar amounts of paper waste as ICE. When recycling rates increase in Costa Rica, it is possible that ICE may be able to collect this quantity of paper in the future. However, ICE should not prioritize the collection of this magnitude of paper as a short-term goal.

CHAPTER FIVE: RECOMMENDATIONS

Based on our research and our cost-benefit analysis, we determined that ICE's current amount of paper waste generation does not warrant the construction of a paper recycling plant. In this chapter, we offer six recommendations for ICE with regards to recycling.

RECOMMENDATION 1: DO NOT CONSTRUCT A PAPER RECYCLING PLANT

Based on our findings, **we do not recommend that ICE construct an internal paper recycling plant under the current collection rates and with equipment designed to process 50 to 1000 metric tons of paper waste per day.** From our cost-benefit analysis, we have found that the costs the recycling plant would be higher than the benefits, and ICE would to lose money continuously on its investment. Additionally, the machinery we have found in our research is too large to fit in the thirty-by-thirty meter building set aside in Pavas. Even at ICE's goal of collecting 90 percent, building a paper recycling plant would not be feasible.

RECOMMENDATION 2: CONTINUE RESEARCH ABOUT PAPER RECYCLING MACHINERY

If ICE is still interested in constructing its own recycling plant then **we recommend that ICE continue research about paper recycling machinery.** We were unable to locate manufacturers of equipment for smaller scale recycling operations. However, with more research and more company contacts, it is possible that ICE could find manufacturers of paper recycling equipment that would better fit its needs.

Additionally, we recommend that ICE do more research on the sizes of the recycling machinery. We anticipate that a paper recycling plant that completes the recycling process up to the creation of usable wet lap would not be possible in the current building set aside in Pavas.

RECOMMENDATION 3: KEEP ACCURATE RECORDS OF PAPER WASTE

We recommend that ICE keep more accurate measurements of the paper waste that is generated. This would be helpful for future recycling projects or if ICE continues to research machinery for a paper recycling plant. We suggest that a database be created which to contain information regarding paper purchases made by ICE. The database should contain quantities, types, costs, and weights of the paper purchases. Paper that is unrecyclable should be excluded from this new database. In addition, a separate database should be created to document paper purchased with petty cash. Employees should be instructed to keep a record of the paper products that they personally purchase. We recommend that employees submit information about the paper products they purchase so that this information can be more accurately recorded.

RECOMMENDATION 4: COLLECT MORE PAPER WASTE

In order to make the recycling plant profitable using equipment found in our research, **ICE should collect a larger quantity of paper.** ICE's current paper waste collection is approximately 155 metric tons per year, which is not enough to warrant building the recycling plant. The paper recycling machinery that we have found is designed for a minimum of 50 metric tons of paper waste per day. ICE's current collection rate of only 30 percent of its paper waste per year equates to approximately 0.42 metric tons per day. If ICE were to reach its projected goal of a 90 percent recycling rate, ICE would still not be producing enough paper waste to make purchasing paper recycling equipment a profitable investment. ICE would have to increase its paper collection to a minimum of 42 metric tons per day in order for a paper recycling plant to be profitable. This means that ICE would need to increase its collection by 100 times its current rate.

In order to collect a minimum of 42 metric tons of paper, **we recommend that ICE consider collecting paper from other government agencies in Costa Rica.** According to our cost-benefit analysis, a collection rate of approximately 42 metric tons of paper waste per day would make a recycling plant profitable. ICE should research the paper waste generation and recycling rates within these companies and organizations to determine if collecting their paper waste could allow ICE to meet at least 42 metric tons of paper waste per day. Andritz suggested that if ICE manages to collect enough paper, ICE should research systems in which the final product is wet lap at approximately 50 percent moisture. Wet lap systems are significantly less expensive than machines used to create rolls of dry paper. **We recommend further research on Costa Rica's paper market to determine whether a wet lap system would be profitable.**

RECOMMENDATION 5: CONTINUE AGREEMENT WITH KIMBERLY-CLARK

Based on the current situation in which ICE does not construct a recycling plant, **we recommend that ICE continue the agreement with Kimberly-Clark**. For the amount of paper waste currently being collected, the agreement with Kimberly-Clark is beneficial to ICE. The current contract is worth ₡12,000,000 per year, but under a 90 percent recycling rate the value could triple to ₡36,000,000 per year. Additionally, the money not being spent on an internal recycling plant can be invested into a future project.

RECOMMENDATION 6: CONSIDER PURCHASING NEW SHREDDERS AND BALERS

While the current space set aside in Pavas is not large enough for a paper recycling plant with recycling equipment made to process 50 to 1000 tons of paper waste per day, ICE could still use this space to expedite its paper collecting process. **We recommend that ICE consider purchasing new shredders and balers to be placed in the building set aside in Pavas. We also recommend that ICE consider hiring more employees to operate the new shredders**

and balers and specifically focus on the collection and organization of paper waste. This may be an efficient way to facilitate the processing of paper waste.

The current building in Pavas would be appropriate for expediting ICE's paper waste collection because it is suitable for a few machines and has enough space to organize ICE's current paper waste. If ICE were to successfully expedite its paper collection and recycling process then the current agreement with Kimberly-Clark would increase in value.

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APPENDIX A: MISSION AND ORGANIZATION OF ICE

The *Instituto Costarricense de Electricidad* (ICE) is a government organization that provides electricity and telecommunications services to Costa Rica. The company is currently a monopoly over both the electricity and telecommunications services in Costa Rica, although the telecommunications division of ICE is currently undergoing privatization.

ICE was founded on April 8, 1949, as an answer to a shortage of electricity in Costa Rica. ICE has since built power plants to aid in the development of the country. ICE started a telecommunications division in 1963 as a solution to the country's need for telephone service provider. Later, ICE added another division to the company to provide internet service to Costa Rica. Currently, ICE exists as a group of several sub-companies. It is composed of ICE *Sector Electricidad*, which provides electricity service, ICE *Sector Telecommunicaciones*, which provides phone service, *Radiográfica Costarricense*, which provides internet service, *Compañía Nacional de Fuerza y Luz*, and *Compañía Radiográfica Internacional*. ICE currently has approximately 24,000 employees working in its various sub-companies. These companies share the same mission and vision as well as central headquarters.

According to ICE's website, the mission of ICE is to "serve the markets of both the electric industry and of the telecommunications and information, with levels of international competitiveness, through an approach of multiple services and applications, to satisfy the growing and varied needs of the clients, maintaining a leading position in the new segments of these industries and associated segments, according to the legal framework." ICE's vision is to be a "competitive leader in the telecommunications, information, and electric industry markets with the best technology and human resources for customer service and the Costa Rican society, contributing in the economic development, both social and environmentally, promoting the

universality of service at the national level and the rational use of natural resources."

APPENDIX B: PAPER RECYCLING PROCESS

It is important for the reader to be familiar with the process of paper recycling in order to better understand the requirements of this project. Paper recycling is fundamentally simple but creating a recycling plant can be complicated and expensive. The basic recycling process includes breaking down used paper, removing contaminants, and forming it into a usable paper product (Gateshead Council, 2008). Depending on the final product this process varies slightly.

Paper is one of the easiest materials to recycle (Recycle Now, 2008). The entire recycling process can take as little as seven days (Recycle Now, 2008). However, the quality of paper decreases each time it is recycled (Tappi, 2001). The fibers become increasingly shorter as the process continues, and the paper loses its strength. As a result, the recycling process can only be completed approximately five of six times before the paper fibers become too small to stay together (Gateshead Council, 2008, Tappi, 2001, The City of Edinburgh Council, 2008, Woodland Trust, 2008, Waste Online, 2008).

The first step in the recycling process is collection. This step is vital as it provides the raw material used to create recycled paper. Paper must be collected and brought to a recycling facility. In an office environment paper is usually collected in bins that are combined into a larger stockpile on a regular basis. Many recycling companies will then pick up the paper and bring it to their recycling facility. At the facility the paper is put into large bales and stored until it is needed (The City of Edinburgh Council, 2008).

When the recycling facility is ready to process the paper, it enters the recycling process. The first step of this process is called pulping, which involves breaking paper down into smaller pieces. The paper is first physically shredded into coarse pieces and then heated with water and

chemicals to break it down into tiny fibers (Tappi, 2001). The resulting pulp is the basis for the recycled paper, but it must be further treated before it is usable.

After becoming pulp, the mixture enters the screening process. Smaller contaminants such as plastic pieces and adhesive are filtered out (Tappi, 2001). Then the pulp is further cleaned in spinning cone-shaped cylinders. Heavy contaminants such as staples and paperclips are thrown out of the cylinder and removed (Tappi, 2001).

Depending on the intended final product, the pulp may then go through the de-inking process. If the paper is to be recycled into new white paper, the ink from the previous use has to be removed. For products such as brown cardboard, this process is unnecessary. First, the pulp soaks in whitening chemicals, such as hydrogen peroxide, chlorine dioxide, or oxygen, for several hours until it is brighter and whiter (Tappi, 2001). Then, the pulp is mixed with surfactants to remove the ink. Surfactants stick to the ink, contaminants, and small fibers, and float to the surface of the pulp where they are removed from the mixture. The removed material can be burned for energy, composted, or simply put into landfills (Recover Incorporated, 2008).

After de-inking, the paper is ready to be formed. There are several different ways to form sheets of paper. One method involves mixing the pulp with water and chemicals until it is about 95 percent liquid. A machine then sprays this mixture onto a wire screen where the water drains out and the paper fibers remain. Heated rollers help dry and flatten the paper into a usable form (Tappi, 2001). Another method for forming paper sheets is to simply pump the pulp between two wire screens. These screens are then flattened together to remove water and create a smooth sheet (The City of Edinburgh Council, 2008).

Once the paper is flattened and dried, it is wound into large rolls (The City of Edinburgh Council, 2008). These can be as large as thirty feet wide and can weigh as much as twenty tons

(Tappi, 2001). These large rolls of paper are then sent to a plant where they can be cut into smaller sheets of paper or made into paper products such as envelopes, paper bags, or boxes (Tappi, 2001).

APPENDIX C: RECYCLING IN OTHER COMPANIES

The following section briefly describes the recycling methods that other companies are currently using. This information further confirmed our conclusion that building a recycling plant is not usually financially feasible in companies outside the paper industry.

Bank of America. Bank of America, the largest bank in the United States, strongly emphasizes the importance of recycling. Bank of America recycles 45,359 metric tons of paper per year, which according to their website exceeds their consumption for internal operations. However, despite the large quantity, Bank of America does not have an internal recycling plant. Instead, the recyclable paper is shipped to an external company for processing. According to the Bank of America website (bankofamerica.com), this paper is an important source of revenue for the bank.

Apple Computer, Inc. Another company we researched was Apple Computer, Inc. Apple develops computer hardware and software, as well as other consumer electronics. Apple has 21,500 employees according to a 2007 CNN report on job growth. This compares similarly to 24,000 employees at ICE. According to its website (www.apple.com), Apple recycles wastepaper, glass, metals, and plastics. Wastepaper, including cardboard packaging and printed materials, is sent to external processing facilities where it undergoes the recycling process.

Phase Forward. Phase Forward is a Massachusetts company that develops data management solutions for the medical industry. Our project group interviewed Phase Forward in September 2008. According to a 2005 annual report, Phase Forward employs 409 workers. Phase Forward hires a paper shredding company to shred all of its confidential documents. The shredding company then sends the paper to a paper recycling plant to be recycled.

National Grid. National Grid is an electricity and natural gas provider in the northeastern United States. National Grid has an Investment Recovery and Recycling Services building in Liverpool, New York, which is staffed by 16 National Grid employees (National Grid, 2008). Reusable materials are taken from the company's waste stream and stored it in the building in New York. Ultimately, the material is sold to a recycling company. This is similar to the situation ICE has with Kimberly-Clark.

APPENDIX D: NPV FOR 30 PERCENT RECYCLING RATE

Cash Flow	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Machinery	₡33,519,000,000	₡0	₡0	₡0	₡0	₡0
Employees	₡133,882,020	₡144,592,582	₡156,159,988	₡168,652,787	₡182,145,010	₡196,716,611
Electricity	₡11,160,000	₡11,160,000	₡11,160,000	₡11,160,000	₡11,160,000	₡11,160,000
Water	₡3,010,689	₡3,010,689	₡3,010,689	₡3,010,689	₡3,010,689	₡3,010,689
Maintenance	₡0	₡1,675,950,000	₡2,346,330,000	₡3,016,710,000	₡3,687,090,000	₡4,357,470,000
Insurance	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000
Agreement with Kimberly-Clark	₡12,000,000	₡12,000,000	₡12,000,000	₡12,000,000	₡12,000,000	₡12,000,000
Total Costs	₡33,746,090,709	₡1,913,751,271	₡2,595,698,677	₡3,278,571,476	₡3,962,443,699	₡4,647,395,300
Present Value Costs	₡33,746,090,709	₡1,693,585,195	₡2,032,812,810	₡2,272,214,494	₡2,430,240,928	₡2,522,419,976
Sales of Wet-Lap	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088
Total Benefits	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088
Present Value Benefits	₡119,729,088	₡105,954,945	₡93,765,438	₡82,978,264	₡73,432,092	₡64,984,152
Yearly Net Present Value	-₡33,626,361,621	-₡1,587,630,250	-₡1,939,047,372	-₡2,189,236,230	-₡2,356,808,836	-₡2,457,435,823
Cumulative Net Present Value	-₡33,626,361,621	-₡35,213,991,871	-₡37,153,039,243	-₡39,342,275,473	-₡41,699,084,309	-₡44,156,520,132

Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13
₡0	₡0	₡0	₡0	₡0	₡0	₡0
₡212,453,940	₡229,450,255	₡247,806,275	₡267,630,777	₡289,041,240	₡312,164,539	₡337,137,702
₡11,160,000	₡11,160,000	₡11,160,000	₡11,160,000	₡11,160,000	₡11,160,000	₡11,160,000
₡3,010,689	₡3,010,689	₡3,010,689	₡3,010,689	₡3,010,689	₡3,010,689	₡3,010,689
₡5,027,850,000	₡5,698,230,000	₡6,368,610,000	₡7,038,990,000	₡7,709,370,000	₡8,379,750,000	₡9,050,130,000
₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000
₡12,000,000	₡12,000,000	₡12,000,000	₡12,000,000	₡12,000,000	₡12,000,000	₡12,000,000
₡5,333,512,629	₡6,020,888,944	₡6,709,624,964	₡7,399,829,466	₡8,091,619,929	₡8,785,123,228	₡9,480,476,391
₡2,561,784,932	₡2,559,242,930	₡2,523,891,599	₡2,463,290,999	₡2,383,696,948	₡2,290,261,009	₡2,187,201,722
₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088
₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088
₡57,508,099	₡50,892,123	₡45,037,277	₡39,855,998	₡35,270,794	₡31,213,092	₡27,622,206
-₡2,504,276,833	-₡2,508,350,807	-₡2,478,854,322	-₡2,423,435,001	-₡2,348,426,154	-₡2,259,047,916	-₡2,159,579,517
-₡46,660,796,965	-₡49,169,147,772	-₡51,648,002,094	-₡54,071,437,095	-₡56,419,863,250	-₡58,678,911,166	-₡60,838,490,683

Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
₡0	₡0	₡0	₡0	₡0	₡0	₡0
₡364,108,718	₡393,237,416	₡424,696,409	₡458,672,121	₡495,365,891	₡534,995,163	₡577,794,776
₡11,160,000	₡11,160,000	₡11,160,000	₡11,160,000	₡11,160,000	₡11,160,000	₡11,160,000
₡3,010,689	₡3,010,689	₡3,010,689	₡3,010,689	₡3,010,689	₡3,010,689	₡3,010,689
₡9,720,510,000	₡10,390,890,000	₡11,061,270,000	₡11,731,650,000	₡12,402,030,000	₡13,072,410,000	₡13,407,600,000
₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000
₡12,000,000	₡12,000,000	₡12,000,000	₡12,000,000	₡12,000,000	₡12,000,000	₡12,000,000
₡10,177,827,407	₡10,877,336,105	₡11,579,175,098	₡12,283,530,810	₡12,990,604,580	₡13,700,613,852	₡14,078,603,465
₡2,077,951,069	₡1,965,279,570	₡1,851,403,025	₡1,738,073,443	₡1,626,656,393	₡1,518,196,701	₡1,380,604,074
₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088
₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088	₡119,729,088
₡24,444,430	₡21,632,239	₡19,143,574	₡16,941,216	₡14,992,227	₡13,267,457	₡11,741,112
-₡2,053,506,639	-₡1,943,647,331	-₡1,832,259,451	-₡1,721,132,227	-₡1,611,664,166	-₡1,504,929,244	-₡1,368,862,962
-₡62,891,997,322	-₡64,835,644,653	-₡66,667,904,104	-₡68,389,036,331	-₡70,000,700,498	-₡71,505,629,741	-₡72,874,492,703

APPENDIX E: NPV FOR 90 PERCENT RECYCLING RATE

Cash Flow	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Machinery	₡33,519,000,000	₡0	₡0	₡0	₡0	₡0
Employees	₡133,882,020	₡144,592,582	₡156,159,988	₡168,652,787	₡182,145,010	₡196,716,611
Electricity	₡33,408,000	₡33,408,000	₡33,408,000	₡33,408,000	₡33,408,000	₡33,408,000
Water	₡9,012,643	₡9,012,643	₡9,012,643	₡9,012,643	₡9,012,643	₡9,012,643
Maintenance	₡0	₡1,675,950,000	₡2,346,330,000	₡3,016,710,000	₡3,687,090,000	₡4,357,470,000
Insurance	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000
Agreement with Kimberly-Clark	₡36,000,000	₡36,000,000	₡36,000,000	₡36,000,000	₡36,000,000	₡36,000,000
Total Costs	₡33,798,340,663	₡1,966,001,225	₡2,647,948,631	₡3,330,821,430	₡4,014,693,653	₡4,699,645,254
Present Value Costs	₡33,798,340,663	₡1,739,824,093	₡2,073,732,188	₡2,308,426,333	₡2,462,286,803	₡2,550,779,157
Sales of Wet-Lap	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400
Total Benefits	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400
Present Value Benefits	₡356,990,400	₡315,920,708	₡279,575,848	₡247,412,255	₡218,948,898	₡193,760,087
Yearly Net Present Value	-₡33,441,350,263	-₡1,423,903,385	-₡1,794,156,341	-₡2,061,014,078	-₡2,243,337,906	-₡2,357,019,071
Cumulative Net Present Value	-₡33,441,350,263	-₡34,865,253,648	-₡36,659,409,989	-₡38,720,424,067	-₡40,963,761,972	-₡43,320,781,043

Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13
₡0	₡0	₡0	₡0	₡0	₡0	₡0
₡212,453,940	₡229,450,255	₡247,806,275	₡267,630,777	₡289,041,240	₡312,164,539	₡337,137,702
₡33,408,000	₡33,408,000	₡33,408,000	₡33,408,000	₡33,408,000	₡33,408,000	₡33,408,000
₡9,012,643	₡9,012,643	₡9,012,643	₡9,012,643	₡9,012,643	₡9,012,643	₡9,012,643
₡5,027,850,000	₡5,698,230,000	₡6,368,610,000	₡7,038,990,000	₡7,709,370,000	₡8,379,750,000	₡9,050,130,000
₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000
₡36,000,000	₡36,000,000	₡36,000,000	₡36,000,000	₡36,000,000	₡36,000,000	₡36,000,000
₡5,385,762,583	₡6,073,138,898	₡6,761,874,919	₡7,452,079,421	₡8,143,869,883	₡8,837,373,182	₡9,532,726,345
₡2,586,881,553	₡2,581,452,330	₡2,543,545,934	₡2,480,684,216	₡2,399,089,176	₡2,303,882,449	₡2,199,256,095
₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400
₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400
₡171,469,103	₡151,742,569	₡134,285,460	₡118,836,690	₡105,165,212	₡93,066,559	₡82,359,787
-₡2,415,412,450	-₡2,429,709,760	-₡2,409,260,475	-₡2,361,847,526	-₡2,293,923,964	-₡2,210,815,890	-₡2,116,896,307
-₡45,736,193,493	-₡48,165,903,253	-₡50,575,163,728	-₡52,937,011,255	-₡55,230,935,218	-₡57,441,751,108	-₡59,558,647,415

Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
₡0	₡0	₡0	₡0	₡0	₡0	₡0
₡364,108,718	₡393,237,416	₡424,696,409	₡458,672,121	₡495,365,891	₡534,995,163	₡577,794,776
₡33,408,000	₡33,408,000	₡33,408,000	₡33,408,000	₡33,408,000	₡33,408,000	₡33,408,000
₡9,012,643	₡9,012,643	₡9,012,643	₡9,012,643	₡9,012,643	₡9,012,643	₡9,012,643
₡9,720,510,000	₡10,390,890,000	₡11,061,270,000	₡11,731,650,000	₡12,402,030,000	₡13,072,410,000	₡13,407,600,000
₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000
₡36,000,000	₡36,000,000	₡36,000,000	₡36,000,000	₡36,000,000	₡36,000,000	₡36,000,000
₡10,230,077,361	₡10,929,586,059	₡11,631,425,052	₡12,335,780,765	₡13,042,854,534	₡13,752,863,806	₡14,130,853,419
₡2,088,618,655	₡1,974,719,911	₡1,859,757,310	₡1,745,466,615	₡1,633,199,023	₡1,523,986,639	₡1,385,727,913
₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400
₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400	₡356,990,400
₡72,884,767	₡64,499,794	₡57,079,464	₡50,512,800	₡44,701,593	₡39,558,932	₡35,007,904
-₡2,015,733,887	-₡1,910,220,117	-₡1,802,677,846	-₡1,694,953,815	-₡1,588,497,430	-₡1,484,427,707	-₡1,350,720,009
-₡61,574,381,303	-₡63,484,601,420	-₡65,287,279,266	-₡66,982,233,081	-₡68,570,730,511	-₡70,055,158,219	-₡71,405,878,228

APPENDIX F: NPV FOR 42 TONS OF PAPER PER DAY

Cash Flow	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Machinery	₡33,519,000,000	₡0	₡0	₡0	₡0	₡0
Employees	₡133,882,020	₡144,592,582	₡156,159,988	₡168,652,787	₡182,145,010	₡196,716,611
Electricity	₡1,103,760,000	₡1,103,760,000	₡1,103,760,000	₡1,103,760,000	₡1,103,760,000	₡1,103,760,000
Water	₡297,766,890	₡297,766,890	₡297,766,890	₡297,766,890	₡297,766,890	₡297,766,890
Maintenance	₡0	₡1,675,950,000	₡2,346,330,000	₡3,016,710,000	₡3,687,090,000	₡4,357,470,000
Insurance	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000
Agreement with Kimberly-Clark	₡994,378,378	₡994,378,378	₡994,378,378	₡994,378,378	₡994,378,378	₡994,378,378
Total Costs	₡36,115,825,288	₡4,283,485,850	₡4,965,433,257	₡5,648,306,056	₡6,332,178,279	₡7,017,129,879
Present Value Costs	₡36,115,825,288	₡3,790,695,442	₡3,888,662,586	₡3,914,559,428	₡3,883,643,525	₡3,808,616,964
Sales of Wet-Lap	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792
Total Benefits	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792
Present Value Benefits	₡11,787,273,792	₡10,431,215,745	₡9,231,164,376	₡8,169,172,014	₡7,229,355,765	₡6,397,659,969
Yearly Net Present Value	-₡24,328,551,496	₡6,640,520,303	₡5,342,501,790	₡4,254,612,586	₡3,345,712,240	₡2,589,043,005
Cumulative Net Present Value	-₡24,328,551,496	-₡17,688,031,194	-₡12,345,529,404	-₡8,090,916,818	-₡4,745,204,578	-₡2,156,161,573

Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14
₡0	₡0	₡0	₡0	₡0	₡0	₡0	₡0
₡212,453,940	₡229,450,255	₡247,806,275	₡267,630,777	₡289,041,240	₡312,164,539	₡337,137,702	₡364,108,718
₡1,103,760,000	₡1,103,760,000	₡1,103,760,000	₡1,103,760,000	₡1,103,760,000	₡1,103,760,000	₡1,103,760,000	₡1,103,760,000
₡297,766,890	₡297,766,890	₡297,766,890	₡297,766,890	₡297,766,890	₡297,766,890	₡297,766,890	₡297,766,890
₡5,027,850,000	₡5,698,230,000	₡6,368,610,000	₡7,038,990,000	₡7,709,370,000	₡8,379,750,000	₡9,050,130,000	₡9,720,510,000
₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000
₡994,378,378	₡994,378,378	₡994,378,378	₡994,378,378	₡994,378,378	₡994,378,378	₡994,378,378	₡994,378,378
₡7,703,247,208	₡8,390,623,523	₡9,079,359,544	₡9,769,564,046	₡10,461,354,508	₡11,154,857,807	₡11,850,210,970	₡12,547,561,986
₡3,700,012,356	₡3,566,523,836	₡3,415,290,631	₡3,252,139,700	₡3,081,793,144	₡2,908,045,252	₡2,733,913,442	₡2,561,766,750
₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792
₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792
₡5,661,645,990	₡5,010,306,186	₡4,433,899,280	₡3,923,804,672	₡3,472,393,515	₡3,072,914,615	₡2,719,393,465	₡2,406,542,889
₡1,961,633,635	₡1,443,782,350	₡1,018,608,649	₡671,664,973	₡390,600,372	₡164,869,363	-₡14,519,978	-₡155,223,861
-₡194,527,939	₡1,249,254,411	₡2,267,863,060	₡2,939,528,033	₡3,330,128,404	₡3,494,997,768	₡3,480,477,790	₡3,325,253,929

Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
₡0	₡0	₡0	₡0	₡0	₡0
₡393,237,416	₡424,696,409	₡458,672,121	₡495,365,891	₡534,995,163	₡577,794,776
₡1,103,760,000	₡1,103,760,000	₡1,103,760,000	₡1,103,760,000	₡1,103,760,000	₡1,103,760,000
₡297,766,890	₡297,766,890	₡297,766,890	₡297,766,890	₡297,766,890	₡297,766,890
₡10,390,890,000	₡11,061,270,000	₡11,731,650,000	₡12,402,030,000	₡13,072,410,000	₡13,407,600,000
₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000
₡994,378,378	₡994,378,378	₡994,378,378	₡994,378,378	₡994,378,378	₡994,378,378
₡13,247,070,684	₡13,948,909,677	₡14,653,265,390	₡15,360,339,160	₡16,070,348,431	₡16,448,338,044
₡2,393,435,040	₡2,230,301,671	₡2,073,381,979	₡1,923,389,611	₡1,780,792,469	₡1,612,989,710
₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792
₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792	₡11,787,273,792
₡2,129,683,973	₡1,884,676,082	₡1,667,854,940	₡1,475,977,823	₡1,306,175,065	₡1,155,907,137
-₡263,751,067	-₡345,625,589	-₡405,527,039	-₡447,411,788	-₡474,617,404	-₡457,082,573
₡3,061,502,862	₡2,715,877,272	₡2,310,350,233	₡1,862,938,445	₡1,388,321,040	₡931,238,467

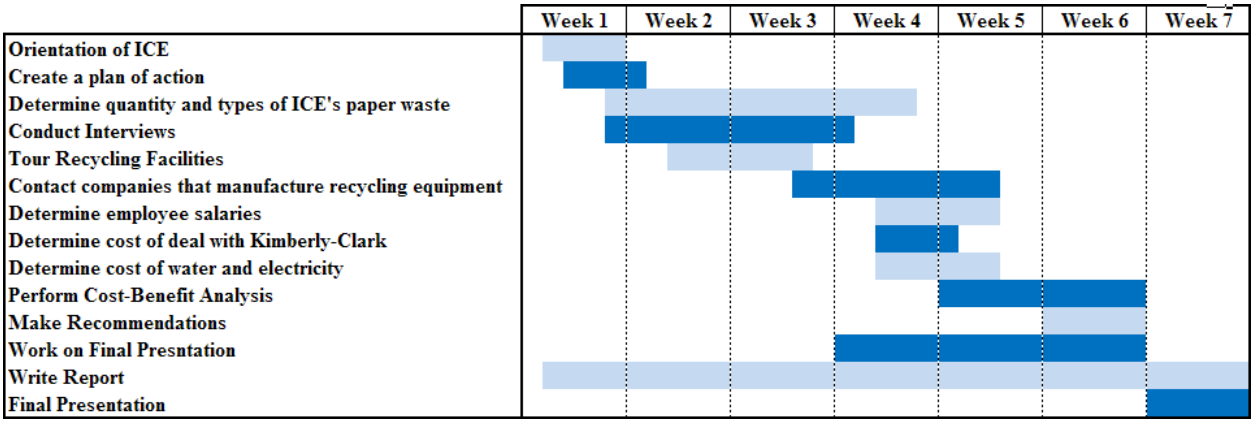
APPENDIX G: NPV FOR 63 TONS OF PAPER PER DAY

Cash Flow	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Machinery	₡33,519,000,000	₡0	₡0	₡0	₡0	₡0
Employees	₡133,882,020	₡144,592,582	₡156,159,988	₡168,652,787	₡182,145,010	₡196,716,611
Electricity	₡1,655,640,000	₡1,655,640,000	₡1,655,640,000	₡1,655,640,000	₡1,655,640,000	₡1,655,640,000
Water	₡446,650,317	₡446,650,317	₡446,650,317	₡446,650,317	₡446,650,317	₡446,650,317
Maintenance	₡0	₡1,675,950,000	₡2,346,330,000	₡3,016,710,000	₡3,687,090,000	₡4,357,470,000
Insurance	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000
Agreement with Kimberly-Clark	₡1,491,567,568	₡1,491,567,568	₡1,491,567,568	₡1,491,567,568	₡1,491,567,568	₡1,491,567,568
Total Costs	₡37,313,777,905	₡5,481,438,466	₡6,163,385,873	₡6,846,258,672	₡7,530,130,895	₡8,215,082,496
Present Value Costs	₡37,313,777,905	₡4,850,830,501	₡4,826,835,205	₡4,744,800,683	₡4,618,370,300	₡4,458,817,650
Sales of Wet-Lap	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688
Total Benefits	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688
Present Value Benefits	₡17,680,910,688	₡15,646,823,618	₡13,846,746,564	₡12,253,758,022	₡10,844,033,647	₡9,596,489,953
Yearly Net Present Value	-₡19,632,867,217	₡10,795,993,117	₡9,019,911,360	₡7,508,957,338	₡6,225,663,348	₡5,137,672,304
Cumulative Net Present Value	-₡19,632,867,217	-₡8,836,874,100	₡183,037,260	₡7,691,994,598	₡13,917,657,946	₡19,055,330,250

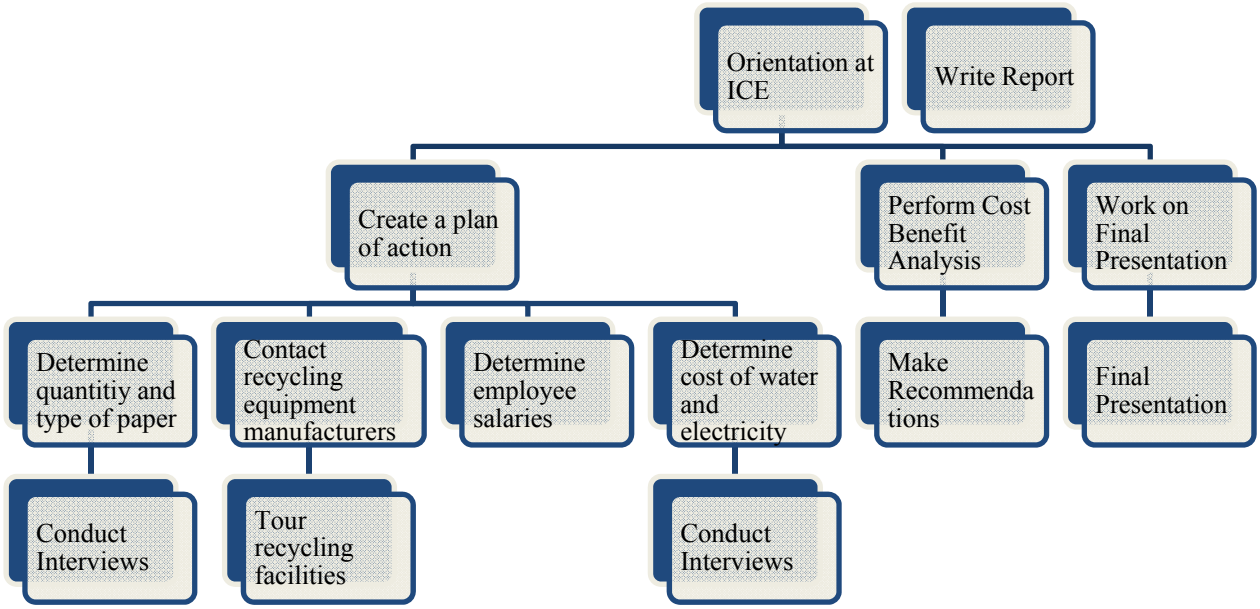
Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14
₡0	₡0	₡0	₡0	₡0	₡0	₡0	₡0
₡212,453,940	₡229,450,255	₡247,806,275	₡267,630,777	₡289,041,240	₡312,164,539	₡337,137,702	₡364,108,718
₡1,655,640,000	₡1,655,640,000	₡1,655,640,000	₡1,655,640,000	₡1,655,640,000	₡1,655,640,000	₡1,655,640,000	₡1,655,640,000
₡446,650,317	₡446,650,317	₡446,650,317	₡446,650,317	₡446,650,317	₡446,650,317	₡446,650,317	₡446,650,317
₡5,027,850,000	₡5,698,230,000	₡6,368,610,000	₡7,038,990,000	₡7,709,370,000	₡8,379,750,000	₡9,050,130,000	₡9,720,510,000
₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000
₡1,491,567,568	₡1,491,567,568	₡1,491,567,568	₡1,491,567,568	₡1,491,567,568	₡1,491,567,568	₡1,491,567,568	₡1,491,567,568
₡8,901,199,824	₡9,588,576,140	₡10,277,312,160	₡10,967,516,662	₡11,659,307,124	₡12,352,810,423	₡13,048,163,587	₡13,745,514,603
₡4,275,411,192	₡4,075,726,347	₡3,865,912,321	₡3,650,919,957	₡3,434,696,026	₡3,220,348,688	₡3,010,288,164	₡2,806,346,150
₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688
₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688
₡8,492,468,985	₡7,515,459,279	₡6,650,848,920	₡5,885,707,008	₡5,208,590,273	₡4,609,371,923	₡4,079,090,197	₡3,609,814,334
₡4,217,057,793	₡3,439,732,933	₡2,784,936,599	₡2,234,787,052	₡1,773,894,247	₡1,389,023,235	₡1,068,802,033	₡803,468,184
₡23,272,388,043	₡26,712,120,976	₡29,497,057,574	₡31,731,844,626	₡33,505,738,873	₡34,894,762,108	₡35,963,564,141	₡36,767,032,325

Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
₡0	₡0	₡0	₡0	₡0	₡0
₡393,237,416	₡424,696,409	₡458,672,121	₡495,365,891	₡534,995,163	₡577,794,776
₡1,655,640,000	₡1,655,640,000	₡1,655,640,000	₡1,655,640,000	₡1,655,640,000	₡1,655,640,000
₡446,650,317	₡446,650,317	₡446,650,317	₡446,650,317	₡446,650,317	₡446,650,317
₡10,390,890,000	₡11,061,270,000	₡11,731,650,000	₡12,402,030,000	₡13,072,410,000	₡13,407,600,000
₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000	₡67,038,000
₡1,491,567,568	₡1,491,567,568	₡1,491,567,568	₡1,491,567,568	₡1,491,567,568	₡1,491,567,568
₡14,445,023,300	₡15,146,862,293	₡15,851,218,006	₡16,558,291,776	₡17,268,301,047	₡17,646,290,660
₡2,609,876,987	₡2,421,843,217	₡2,242,887,772	₡2,073,394,737	₡1,913,540,368	₡1,730,465,727
₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688
₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688	₡17,680,910,688
₡3,194,525,959	₡2,827,014,123	₡2,501,782,410	₡2,213,966,734	₡1,959,262,597	₡1,733,860,705
₡584,648,972	₡405,170,906	₡258,894,638	₡140,571,997	₡45,722,228	₡3,394,978
₡37,351,681,297	₡37,756,852,203	₡38,015,746,840	₡38,156,318,838	₡38,202,041,066	₡38,205,436,044

TASK CHART


Week 1
Week 2
Week 3
Week 4
Week 5
Week 6
Week 7
Orientation of ICE
Create a plan of action
Determine quantity and types of ICE's paper waste
Conduct Interviews
Tour Recycling Facilities
Contact companies that manufacture recycling equipment
Determine employee salaries
Determine cost of deal with Kimberly-Clark
Determine cost of water and electricity
Perform Cost-Benefit Analysis
Make Recommendations
Work on Final Presntation
Write Report
Final Presentation

FLOW CHART


Orientation at ICE
Write Report
Create a plan of action
Perform Cost Benefit Analysis
Work on Final Presentation
Determine quantitiy and type of paper
Contact recycling equipment manufacturers
Determine employee salaries
Determine cost of water and electricity
Make Recommendations
Final Presentation
Conduct Interviews
Tour recycling facilities
Conduct Interviews